MAY 1949

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 41 • NO. 5

1949 Conference Feature—Chicago's South District Filtration Plant

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Engineering Facts about

Johns-Manville TRANSITE* PRESSURE PIPE

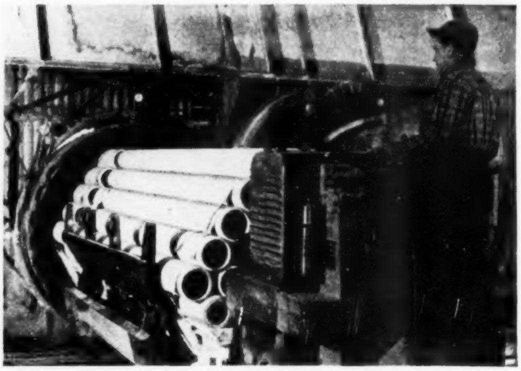
Resistance to Corrosion ...an index of long life

Ability to withstand corrosion is the most important single measure of the durability or life expectancy of an underground water pipe material. Two factors—both inherent in the pipe itself—contribute to Transite's exceptional ability to resist corrosion.

These are:

1. The inherently corrosion-resistant materials of which Transite is made.

2. The specially developed manufacturing process — employed exclusively by Johns-Manville—which imparts a high degree of chemical stability to the finished product.



A load of Transite Pipe about to enter the steam curing tanks. This step in the Johns-Manville manufacturing process contributes substantially to the corrosion resistance of the finished pipe—and, therefore, to its long service life.

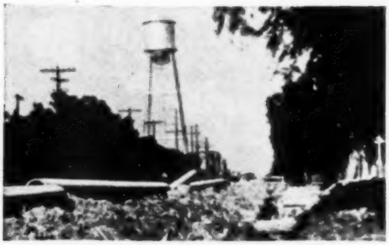
In the manufacture of Transite Pipe, the three basic ingredients, asbestos fibres, cement, and silica—all basically corrosion-resistant by nature—are consolidated under tremendous pressure to form a pipe wall of dense, uniform, homogeneous structure. After forming, the pipe is subjected to a special steam curing process.

It is in this steam curing stage that so much is contributed to the stability and structural integrity of the pipe. Here under the action of pressure steam, Transite assumes a new chemical identity. The silica unites chemically with the free lime ordinarily associated with cement products and converts it into highly stable, insoluble calcium silicates. As a result, the cured pipe is unusually resistant to corrosive attack throughout its entire structure.

This intrinsic resistance to corrosion has been substantiated by numerous installa-

Transite Pipe was first used by this large west coast city in 1933. Its exceptional corrosion resistance—an index of long life—has already made it possible for Transite to outlive other pipe several times over.

***Transite is a registered Johns-Manville trade mark for its asbestos-cement pipe.**



Transite Pipe was installed in this Texas city ten years ago to replace another pipe material that had been destroyed by soil corrosion in 7 years. The Transite mains are still on the job today with a long useful life ahead of them.

tions. Some of these have been exposed to highly aggressive soils, both alkaline and acid, for many years. Many are now serving as replacements for other types of pipe materials under conditions so destructive that their useful service life had been seriously curtailed.

Like thousands of other communities, this West Virginia city selected Transite Pipe because it promised assurance of maximum life. Today, after 14 years of service, the first installation of Transite has already fulfilled this promise by outlasting the pipe material previously used.

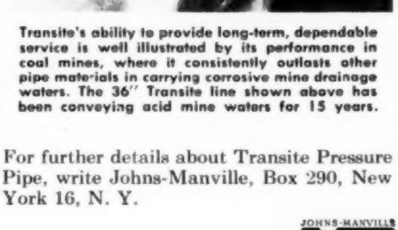
In one such installation, a Transite main installed during 1932 in an extremely corrosive soil was recently made the subject of careful study to determine its condition. Sections of the pipe, including couplings, were dug up and shipped to the factory for test. There was no evidence of deterioration. Pipe and couplings readily withstood the original factory test, equivalent to four times the normal working pressure of the line.

Certain types of industrial service provide an even more severe "proving ground" for the life expectancy of pipe materials, and here, too, Transite Pipe has demonstrated exceptional corrosion resistance. Coal mine service is a typical example. Here acid mine waters are frequently so corrosive that they have destroyed ordinary pipe materials in a matter of a few weeks or months. Yet Transite Pipe has handled these same waters under working pressure up to 150 lbs. for periods from 10 to 15 years with little, if any indication of deterioration.

To evaluate the ability of pipe materials to withstand soil corrosion, the National

Corrosive soil conditions were so severe at this location in a prominent New England city that the life of the pipe material formerly used was only 15 years. Transite Pipe, put in as a replacement in 1934, continues to give the same efficient, dependable service as the day it was installed.

Bureau of Standards has conducted an extensive series of field tests. These studies are based on examination of hundreds of pipe samples periodically removed from severely corrosive soils. In these and similar tests, Transite Pipe has consistently demonstrated its superior resistance to soil corrosion, confirming the long life expectancy which this asbestos-cement pipe has evidenced in thousands of water works installations.



Transite's ability to provide long-term, dependable service is well illustrated by its performance in coal mines, where it consistently outlasts other pipe materials in carrying corrosive mine drainage waters. The 36" Transite line shown above has been conveying acid mine waters for 15 years.

For further details about Transite Pressure Pipe, write Johns-Manville, Box 290, New York 16, N. Y.

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JM
PRODUCTS

COMING MEETINGS

May 12–14—Pacific Northwest Section at Bellingham Hotel, Bellingham, Wash. Secretary, Fred Merryfield, 204 Industrial Bldg., 17th & May Sts., Corvallis, Ore.

A.W.W.A. 1949 ANNUAL CONFERENCE

Stevens Hotel, Chicago **May 30—June 3**

A legal holiday on May 30 will not affect existing plans.

Reservations must be on standard forms and cleared through the A.W.W.A. office.

June 23—New Jersey Section Outing, Wanaque, N.J. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.

LIST OF ADVERTISERS

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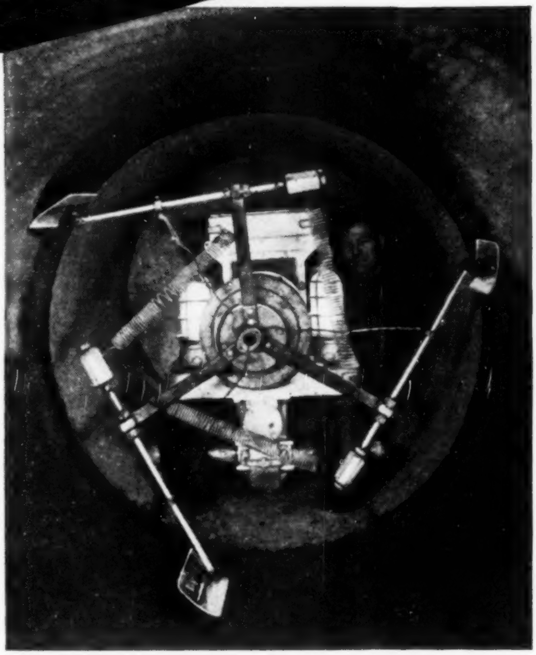

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Departments

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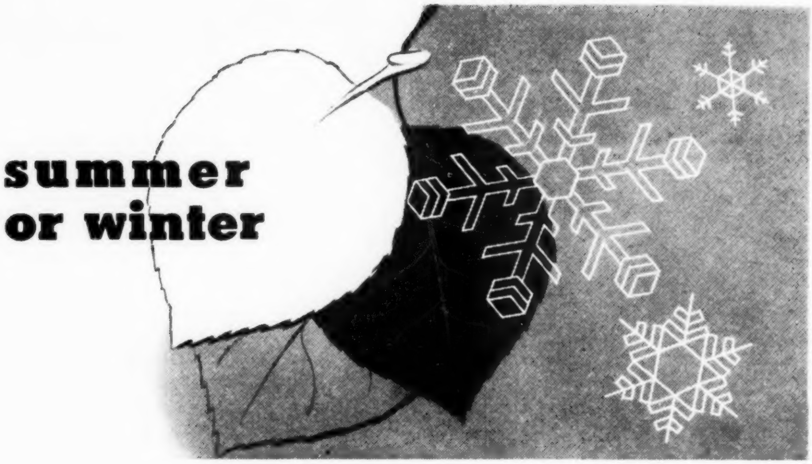

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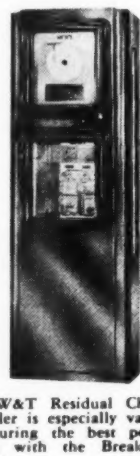
For more details, ask your nearest W&T Representative —he'll be glad to help you.



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Journal

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VOL. 41 • MAY 1949 • NO. 5

San Diego's Accident Prevention Program

By A. George Fish

A paper presented on Oct. 28, 1948, at the California Section Meeting, Riverside, Calif., by A. George Fish, Safety Investigator, Dept. of Public Works, San Diego, Calif.

A CENTRALIZED program has been set up in San Diego to crystallize thinking and action on safety and accident prevention. Under the auspices of the Accident Prevention Committee sponsored by City Manager F. A. Rhodes, the San Diego program deals with the several phases of exposure: industrial accidents, automotive accidents, and public liability and property damage. The first covers approximately 3,000 city employees; the second, some 500 pieces of automotive equipment; and the third, the many miles of sidewalks, streets, sewers and water mains.

San Diego Program

This committee is composed of 25 operating superintendents and their assistants, with Fire Chief George Courser serving as chairman. Regular meetings of an average duration of an hour and a half are held in January, April, July and October. Accidents during the previous period are analyzed and discussed in detail by divisions. Letters of commendation are presented to supervisors operating with no time lost due to injuries during the previous period, and a report is made of the relative standings of the departments, based on accident frequency and severity. Three safety "E" banners, designating first, second and third position, are displayed at the respective division headquarters. These awards are based on the greatest number of elapsed man-hours since the last lost-time accident. Visitors and representatives of the state compensation insurance fund and the Great American Indemnity Co., the city's public liability carrier, have special places on the agenda.

After the close of the calendar year City Manager Rhodes presents plaques of merit to each division superintendent for the skill, dependability and attention to safety demonstrated in operat-

ing during that period without injuries causing lost time. All employees of such divisions are presented with individual pocket pieces bearing the inscription "City Manager's Safety Award" for the year.

Direct contact with operating and supervisory personnel is developed and maintained through a series of monthly safety meetings by the fire and police departments, seven public works divisions and the two water divisions—development and distribution.

Visual aid, using 16-mm. sound film or 35-mm. slide film and records, is a part of each departmental meeting. The subjects are varied, including the use and abuse of tools, proper driving manners, the indoctrination of new employees and topics of general interest. The departmental meetings are held at a regularly scheduled day and hour, and take 45 minutes each, on the city's time.

At these meetings, a general review of the citywide experience is given, together with an analysis of all types of accidents involving the particular department; the object being to prevent the recurrence of similar accidents.

Automobile accidents are analyzed and discussed in a special conference, shortly after the accident, attended by those involved, the dispatcher, the department superintendents and the safety investigator. Disciplinary action, when indicated, is directed by the department superintendent, based on factual information furnished by these special hearings.

Safety bulletin boards are located in the various operating divisions of the city, including the fire and police department shops. These boards, which carry safety posters and information developed from citywide experience, are changed weekly.

Special card records are kept for every type of incident and accident. These are cross-filed with the individual's record and not only reflect the employee's accident proneness, but also furnish the details in automotive accidents, which are classified as chargeable or nonchargeable. This information is transferred to program boards, using red, blue, green and gold stars, which indicate to all attending department meetings those men who were involved in chargeable and nonchargeable automotive accidents or have time lost or nondisabling injuries.

An accident prevention program requires continuous contact with individuals, stressing the need for care, caution and consideration. Although much of the appeal is made to the abstract and intangible, the results are definitely measurable. This approach is coupled with constant observation and on-the-job inspection of operations and work areas in an effort to obtain a state of minimum hazard.

Human Factor

Most accidents result from unsafe conditions or unsafe acts, or both. To prevent accidents, it is necessary to find and remove the cause, without which no accident could occur. Nearly every industrial accident could have been prevented had those directly concerned—the foreman and his men—used good common sense, forethought and planning.

According to one authority, "Approximately 10 per cent of all industrial accidents may be attributed to inadequate mechanical or machine guards and 90 per cent to human er-

rors or defects." San Diego's experience in the years 1945–47 indicated that 94 per cent of the accidents occurring were due to human failure, 6 per cent were chargeable to defective equipment or material and none was due to unguarded equipment. Important as mechanical guards or properly maintained equipment are for the operator, the human factor is ten times as significant as the mechanical. Quite a number of accidents attributable to personnel failure result from lack of rest, poor physical condition, personal problems causing lack of attention to the job, faulty observation or day dreaming, taking chances or shortcuts, or a negligent attitude.

The value and need for mechanical guarding is recognized, and strict attention is given to this phase of safe operation. Ideas secured from various publications are immediately introduced when applicable. San Diego's bible, however, is the code set up by the Div. of Industrial Accidents of the California Dept. of Industrial Relations. Each foreman in the water, sewer and street divisions, for example, has a copy of safety orders covering trench operations, shoring and special equipment needed (1). Barricades, warning signs, flags, lanterns and advance warnings are constantly employed.

Machines may be safely guarded, physical hazards corrected and safe practices established, but accidents will continue to occur until the safety program, through department superintendents and foremen, can convince the men that to work safely is profitable to everyone concerned. Accidents cause the worker pain and suffering, while the time lost reduces his income. Industry is hurt by the loss of manpower, which sometimes requires the training of replacement personnel, and by the loss of time and wasted material. All are affected by the increased cost of insurance due to lower experience ratings and higher loss ratios. Employees must realize that "it is easier to stay well than to get well" and that safeguards are provided to protect the man and not the machine or operation.

In the sphere of automotive accidents, Retail Credit Co. findings indicate that there is no simple method of picking good risks from occupation alone. The causes of accidents appear to stem mainly from the driver—his habits, reputation, age, driving ability, and physical and mental condition. It is concluded that the car and its age have little effect on the accident frequency. Psychophysical tests, as outlined in the motor vehicle supervisor training program, appear to be of great value. However, the best and possibly the only means available at present for protecting the automotive operator is the exercise of caution, courtesy and common sense. A strong and never-ending application of this remedy is indicated.

A recapitulation of municipal service driving from 1943 to 1948 shows an increase in equipment of 55 per cent, while the total of miles traveled has increased 47 per cent, from 2,266,000 to 3,324,000. The number of accidents, however, has been reduced from 1 in 17,000 miles to 1 in 38,000—a decrease of approximately 55 per cent, or an increase of 123.5 per cent in miles traveled per accident.

Accident Insurance

In order to compensate city employees for time lost because of injuries "arising out of and during the

course of their employment," insurance is carried in accordance with the state law. San Diego carries its compensation risk with the State Compensation Insurance Fund, on a dividend basis. In addition, the city, by ordinance, pays full wages for the first seven days of injury leave in the public works division and up to one year's salary in the fire and police departments.

Insurance premiums as given in various manuals are established according to the classification of work and job hazards, and vary from time to time with the results of underwriting experience, both local and state. In addition, an experience modification rate is applied, based on losses sustained and expense incurred. This rate, together with credit for proper machine guarding, provides a material reduction in premiums if the experience is good or above average.

The combination of medical and compensation expense as compared with premiums paid determines the loss ratio. As the accident costs increase, so does the loss ratio, with a corresponding decrease in experience modification rates and dividends.

At one time municipal insurance costs were 139 per cent of the manual rate, but at present the city pays 88 per cent of the established premium by reason of a 12 per cent experience modification rating.

Results of Program

A glance at Table 1, which shows the decrease in 1947 accidents as a percentage of the 1944 incidence, will give an idea of the effectiveness of the San Diego program. The Water Distribution Div. accomplished the outstanding feat of working 170 men over 481,000 man-hours with only one lost-time injury during an eighteen-month period, and two of the seven public works divisions have received awards for completing a calendar year with no time lost due to injuries. It should also be noted that in 1947 the Water Distribution Div. had an accident frequency of 2.81 disabling injuries per million man-hours of exposure and an accident severity of 0.13 days lost per

TABLE 1

Results of Accident Prevention Program

Item	Public Works Dept.		Water Dept. — Distribution Div.		Water Dept. — Development Div.	
	1947—Compared to 1944—*per cent*					
	Increase	Decrease	Increase	Decrease	Increase	Decrease
Personnel	67		107		31	
Man-hours	57		87		13	
Lost-time injuries		46		91		40
Days lost				78		64
Avg. accident frequency		66		95		51
Avg. accident severity		65		89		71

1,000 man-hours of exposure, while the Water Development Div. figures for accident frequency and severity were 21.85 and 0.53, respectively.

In 1945, San Diego paid a compensation premium of $101,335.73, covering an average employee count of 2,024 persons working 4,832,175 man-hours. There were 330 claims, totaling $33,161, which resulted in a loss ratio of 32.7 per cent. The insurance dividend was 55 per cent, or $55,734.65. Although in 1946 the cash return was not so great, the rate classifications were reduced from 43 to 9 in number, with an appreciable reduction in the premium charge. The manpower average increased to 2,406, working over 5,500,000 man-hours. The hazards of fire and police department activities, together with special coverage for these departments under Section 3212 of the Industrial Accident Commission code, resulted in increased losses due to permanent-disability and heart attack awards. Nevertheless, the city was able to earn a dividend of 30.5 per cent on a premium of $116,213.61 actually paid. This dividend, together with the experience modification rating, reflected a saving of $54,363.64, or approximately 40 per cent of the standard manual rates.

Conclusion

Education, coupled with other safety work—especially the determination and publicizing of previous accident causes—will eventually help solve the tremendous problem of accident prevention. The primary requirement in accident prevention is the right spirit and attitude on the part of all concerned. It is necessary to believe in the work and be certain that improvement is possible. Conviction and enthusiasm are mandatory on every level of employment. All authorities point up the need for top management to be safety-minded. It must be enthusiastic not only to endorse, but also to enforce, those procedures which it feels will best accomplish the desired results. Furthermore, top-level supervisors must set an example for their subordinates to follow, particularly in automotive safety.

It has been said that some programs bog down because of the feeling that a safety and accident prevention program is a fine idea only if it doesn't cost anything. In the author's opinion the San Diego program is justified by its results:

1. It has met with some degree of financial success.
2. Pain and suffering due to injuries have been reduced.
3. Trained personnel have been kept on the job with pride in good work done safely.
4. Lost time and damage to material and equipment have been considerably reduced.
5. The feeling of safety-mindedness has been substantially increased and supervision standards have been raised.

Reference

1. Trench Construction Safety Orders. California Div. of Industrial Safety (1945); *these and other safety rules and orders are for sale by the Div. of Industrial Safety, Dept. of Industrial Relations, 965 Mission St., San Francisco 5, Calif.*

Cross Connection Control at Houston

By Clyde R. Harvill, Charles Micha and W. J. Bale

A paper presented on Oct. 12, 1948, at the Southwest Section Meeting, Galveston, Tex., by Clyde R. Harvill, San. Engr.; Charles Micha, Sr. Engr.; and W. J. Bale, Sr. Engr.; all of Water Div., Utilities Dept., Houston, Tex.

A RATHER hasty review of the literature reveals that the whole subject of cross connections is still in a somewhat confused state. The terminology has undergone a complete revision in the past ten years, and perhaps it would be in order at the outset to define some of the terms. The Houston Water Div. follows, as far as possible, the techniques and practices advocated by the U.S. Public Health Service, as interpreted by the Texas health department. The 1946 edition of the U.S.P.H.S. "Manual of Recommended Water Sanitation Practice" (1) gives the following definitions:

1. *Cross Connection*—Any physical connection or arrangement of pipes between two otherwise separate water supply systems, one of which contains potable water and the other water of unknown or questionable safety, whereby water may flow from one system to the other, the direction of flow depending upon the pressure differential between the two systems. In general, no physical cross connection should be permitted between a public or private water distribution system containing potable water and any other system containing water of questionable quality or any other contaminating or polluting substance.

2. *Open Connection*—A piping arrangement which provides an air gap between two water supply systems and which may become a cross connection or interconnection by the insertion of a length of pipe into the air gap. Open connections, physically separated, may be permissible under regulation and supervision by the local or state health department.

3. *Backflow Connection*—Any arrangement whereby the flow of water or other liquids into the distribution system of a potable supply of water can occur from any source or sources other than its intended source. House or industrial toilet or sink fixtures capable of back siphonage into the water system should be classed as backflow connections and therefore be prohibited.

4. *Interconnection*—A physical connection between two potable water supply systems. Interconnections may be permissible when approved by the state department of health.

It should also be borne in mind that, according to the U.S.P.H.S. Drinking Water Standards (2), a water supply system "includes the works and auxiliaries for collection, treatment and distribution of the water from the source of supply to the free-flowing outlet of the ultimate consumer."

Houston Control Work

A previously published paper (3) noted that cross connection work was started in Houston in 1929. Approxi-

mately 50 surveys were made and used as a basis for drawing up an ordinance regulating connections to the public water system. In March 1930 the city council passed a cross connection ordinance; and by October 1, 1935, 211 cross connection surveys and 132 resurveys had been made and 134 cross connections eliminated in Houston.

The Houston water department has therefore had over nineteen years' experience in cross connection control work. By October 1, 1948, 1,085 surveys and 790 resurveys of properties had been made. Out of 351 cross connections found, 347 were eliminated, and the other four were in the process of being eliminated. A permanent file is maintained, which is cross-indexed by name of firm, street address of firm and survey file number. From the 442 cross connection surveys in this file a pretty good history of the water supply and water usage of most of the large buildings and properties in Houston may be obtained. Many other properties have been surveyed, but no detailed reports were prepared, as no violation of the city cross connection ordinance was discovered or was considered likely to exist in the future.

No recent published data were found on the status of cross connection work in other cities in the Southwest Section. Dashiell and Whedbee (4) have stated that prior to 1926 cross connections of private and public water systems were permitted in all cities of Texas. By 1930, however, Houston, Dallas, Fort Worth and San Antonio had undertaken the elimination of all cross connections in the water system.

Survey Program

The Houston program may be divided into five types of cross connection work, which will be described briefly:

1. *Surveys of building plans before construction is begun.* Under a recently adopted procedure, the city building inspector notifies the sanitary engineer when the plans for a new building are received in his office, thus giving the engineer an opportunity of checking the plans before a building permit is issued. By this arrangement it is possible to withhold the permit if the plans do not show, or are not revised to show, piping arrangements in accordance with existing city ordinances and good sanitary practice. This procedure has proved highly successful both from the water division's point of view and that of the builder, and is perhaps the most efficient means of eliminating undesirable sanitary conditions before they become dangerous. For example, a company submitted a set of plans which included a proposal to install an aqua-gasoline system, using city water and city pressure as the dispensing force. The gasoline storage tank was to be directly connected with the city water system, and the water, through a system of valves, would replace the gasoline. This cross connection was eliminated by advising the company to alter the plans so that city water would discharge over the top of a surge tank located in the roof trusses and thus operate the aqua-gasoline system by gravity, making back siphonage impossible.

2. *Preliminary surveys of new buildings under construction.* The cross connection engineer approaches the architect or plumber of a building in

its early construction stages and checks the building plans. This procedure makes it possible to correct undesirable plumbing connections before their installation. From the time of the initial examination of the plans to the completion of the building, a careful check is kept on the building during construction to see that the installations are made according to the approved plans and recommendations.

A recent survey of this type was made on a large building under construction. The plans called for city water to be supplied through a 4-in. float inlet into a surge tank in the basement. There was to have been a 1-in. overflow line from the surge tank, with the 4-in. line extending almost to the bottom of the tank. It was recommended instead that an overflow line of at least 4 in. be installed and the inlet line be raised so that it would be 6 in. above the highest level of the overflow line.

3. *Resurveys of properties previously surveyed.* Resurveying is a never ending job which, ideally, should be completed at least every two years. Many of the old properties have undergone a complete revision in the piping layout of their plants because of an expanded building program that has increased water usage. Often the private wells have been taken out of service and the plant is using city water entirely. In some properties where private wells did not exist, they have now been drilled to take care of equipment using a large quantity of water. It is important that these properties be resurveyed at regular intervals and that all drawings and other information pertinent to cross connection work be brought up to date. It should be noted here that once a cross connection has existed there is a tendency for it to occur again as a result of personnel changes within a plant.

A resurvey was conducted on a plant that, before the war, was using its own wells to supply water for industrial purposes and city water for fire protection and office use. This plant underwent a large construction program in which new buildings were added and new equipment was put into service. As the water demand soon exceeded the output of the wells, a connection was made between the fire protection line and the well discharge line, and city water was used to supplement the well supply. The two systems were directly connected to each other without the knowledge of the sanitary engineer's office. After the resurvey, the plant was notified to break the cross connection.

4. *Surveys of properties outside the city limits.* For the most part, surveys beyond city limits are checks on residences and small businesses applying for city water. Many of these establishments have their own wells, generally shallow, with the ever present danger of contamination. It is necessary to ascertain that there is a complete severance of water service from the well before city water is connected to the system. During 1948, 111 such surveys were made. These surveys require a great amount of time, but water service to the outskirts of the city is often critical because of the unsupported distribution mains and small service lines that extend into the outlying districts. Water pressure in these areas frequently is dependent on water consumption and there are times when low pressure exists near the end of a line, a condition which is ideal for back siphonage. The only way of

being sure that no contamination of the public supply by a private supply can occur is to check the service and make certain there is a complete physical break between the city supply and the private supply.

The sanitary engineer approves all contracts for water service outside the city limits before the meter is set. The same is true of contracts for water service within the city limits when the applications show the existence of a private well on the property to be served.

5. *Surveys of old buildings not previously surveyed.* Since no method has thus far been developed to forecast which old buildings do and which do not contain cross connections, the determination of the site for the survey is not based on any fixed procedure. A large building is surveyed when information on alterations is obtained from newspapers, salesmen, well drillers and other sources. If the sanitary engineer's office is notified that a meter is running backward, such a condition is immediately investigated; marked changes in water consumption by an organization are a fertile field for investigation; and consumer complaints sometimes reveal unusual situations.

An example of what an old building can contain may be illustrated by the findings of a survey on one of Houston's schools. The routine investigation of a complaint of bad-tasting water at this school indicated the need for a more detailed study. Accordingly, a cross connection survey of the building was made, which revealed that the school, with an enrollment of approximately 1,400 students, had sanitary fixtures consisting of: eighteen tank type toilets; eight flushometer type toilets, without vacuum breakers; five drinking fountains, with inlets below the basin rim; twelve lavatories; and ten urinals.

During recess, when one or more flushometer toilets were flushed, there was no water at the drinking fountains. Only one flushometer toilet could be flushed at a time and, inasmuch as these toilets were not equipped with vacuum breakers, the chance of back siphonage into the drinking water lines was very good. A further investigation showed that when this school was originally built in 1916 it contained four rooms. At the time of the survey the building had undergone several additions and was a 34-room structure. It was furnished water through a 1-in. meter connected to a 2-in. service line several blocks long which also supplied eighteen meters ahead of the school meter. Obviously the remedy for this dangerous situation required some action by the water department as well as the school authorities. Adequate service was supplied by constructing an 8-in. water main to this area, and the school officials for their part had a larger meter installed, equipped flushometer fixtures with vacuum breakers and raised the level of the drinking fountain inlets.

Conclusions

From this summary of how the Houston program of cross connection control is organized, a few general observations may be made. It has been found that the interest of the public is best served when all city departments concerned with sanitation integrate their work. Cooperation between the health and public works departments, and among the various sections of the water department, is

necessary if cross connection work is to keep up with the vast growth in construction. In Houston, the sanitary engineer is responsible for ascertaining that the cross connection ordinance is complied with. One engineer is assigned full time to cross connection control. He schedules his work on information received from the contract, maintenance and engineering sections of the water department and many other sources. He investigates properties at the request of or on information obtained from any city department, and, in turn, notifies the department concerned of conditions revealed by a survey.

A further essential is the development of a feeling of fellowship between the cross connection engineer and the consumer. Good cooperation from the consumer is usually obtained by employing a little tact, explaining the reasons for the survey and at times showing that a saving can be made by eliminating a potentially dangerous connection.

In the authors' opinion, any adequate cross connection control program demands a competent engineering staff. The scope of the work is continually increasing and at present requires considerable knowledge of most of the industrial usages of water. It is necessary to study the water requirements of a plant for both operation and fire protection before final recommendations on alterations to the plant piping are made. For example, any changes in piping arrangements on a particular property must not result in increased fire insurance rates. On several occasions the recommendations for eliminating a cross connection also resulted in giving the plant a more efficient water supply system. It cannot be overemphasized that a cooperative consumer—one who feels that the sanitary engineer understands his problems, as well as those of protecting the water supply—makes possible a smooth-running cross connection control program.

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Municipal Bond Financing in Texas

By C. C. Crutchfield

A paper presented on Oct. 11, 1948, at the Southwest Section Meeting, Galveston, Tex., by C. C. Crutchfield, Field Consultant, League of Texas Municipalities, Austin, Tex.

ONLY a few years ago Texas was a rural state, but today the majority of Texans live in incorporated cities and towns. Radical shifts in population and extensive industrial development, brought on by the war and continued during the postwar years, have created critical demands for new water facilities and major extensions in cities and towns where such rapid growth was never anticipated. Water systems, even in cities that have not grown, have had greater demands placed upon them because of air conditioning, drought conditions and a general increase in the use of water by all consumers. Additional complications now arise from the demands of many recently completed homes.

The officials of the 704 incorporated cities and towns in Texas are faced with serious financial problems in supplying water for domestic and industrial purposes. All of the 200 cities of over 2,500 population own their water systems, except for San Angelo, Orange, Robstown, Eagle Pass, Navasota, Texas City, Cameron, Dalhart, Memphis and Quanah. The methods being employed to finance improvements and extensions include the use of operating profits from the system and the issuing of tax or revenue bonds. Not all municipalities resort to one of these methods exclusively; some rather use a combination of them. Many of the smaller cities are financing improvements by both tax and revenue bonds.

Tax Bonds

The term "tax bonds" refers to bonded indebtedness which is backed by the full faith and credit of the issuing government, including its power to tax. There is no law directly specifying the maximum amount that any city may issue, but the financial condition of the city is indirectly controlling. All bonds require the approval of the attorney general of Texas, who will not approve an issue unless the city is able to show that it can fully redeem the bonds by setting up a 2 per cent interest and sinking fund within the tax rate limits of the constitution and statutes.

At present many Texas cities have already issued close to the maximum amount permissible in tax bonds. Cities with less than 5,000 population are limited to a tax rate of $1.50 on each $100 of assessed valuation; for larger municipalities, this limit is $2.50 per $100. Home-rule cities with over 5,000 population often have further limitations in their charters. In addition, it should be pointed out that Texas cities and towns must still depend upon ad valorem taxes on real

estate as the principal source of income for general purposes. Usually this source simply does not provide enough money, nor can it be adequately increased within practical limits. Although citizens living within the corporate boundaries of cities and towns are the greatest taxpayers, the municipalities are tax-poor. County, state and federal taxes absorb the bulk of the total collections, none of which is refunded to the cities to provide public services for urban activities that, in turn, produce the taxable wealth.

During this period of inflated values many cities have found it necessary to revalue both real and personal property for tax purposes. In this way, some cities have increased their valuations so that they could float a new general-obligation bond issue without increasing the tax rate. Where this has been done, the tax officials have usually taken a valuation comparable to the sale price of real estate during 1941 and 1942.

City officials are faced with a serious problem when they call an election for the approval of tax bonds. Materials, labor and construction costs are now very high. But when the bonds are to be retired low tax values may be in effect and a city may have difficulty in retiring the bonds. Therefore, before issuing bonds all factors should be considered to see if the city can pay the cost of the improvement on a reduced revenue in future years. Although interest rates on bonds are very low at present, it has been predicted that they will increase during the coming years. Both large and small cities have recently been able to sell their bonds at very low rates. Taylor, Tex., sold \$65,000 worth of tax bonds at an interest rate of 3½ per cent; Morton, \$100,000 at 3½ to 4 per cent; Vernon, \$400,000 at 3 per cent; Austin, \$1,183,000 at a 2.35 per cent true interest rate; and Dallas, \$3,580,000 at a 2.05 per cent true interest rate.

Article 823 of the Revised Civil Statutes provides the authority for cities to issue tax bonds for water works systems. In addition, there are other specific provisions of state law which must be followed in the issuance of tax bonds. Because of the complexity of these statutes and the fact that city attorneys will assist water works personnel in the actual issuance of the bonds, it does not seem worth while to go into the details of this type of obligation.

A good financial condition is necessary not merely to obtain the approval of the attorney general on a bond issue, but also to sell the bonds to investors. It is suggested that any municipality considering the issuance of tax bonds retain the services of a good consulting engineer to make proper plans and estimates on the needed improvements. In addition, the assistance or advice of a good bond man should be sought. Unless these steps are taken, the city may be unable either to sell the bonds or to get a contractor who will bid within the limit authorized for the project.

Revenue Bonds

All cities and towns in Texas may issue revenue bonds to finance their water systems. These obligations are not considered a debt of the city and consequently are not subject to the same constitutional and statutory restrictions as tax bonds. They must be payable solely out of the revenues from the system, because the law requires each bond to contain the clause: "The

holder hereof shall never have the right to demand payment of this obligation out of the funds raised or to be raised by taxation."

A water system cannot be encumbered for more than $5,000 except for purchase money, or for refunding existing indebtedness, unless the proposed revenue bond issue is approved by a majority of the qualified voters at an election identical to that required for tax obligations. A city may buy or build its system without a special election, but the Bond and Warrant Law of 1931 (Art. 2368a, Vernon's Texas Statutes) requires that notice of intention to purchase or build be published before the governing body actually issues the instruments of indebtedness. If 10 per cent of the qualified voters who are taxpayers in the city should petition for an election prior to the time fixed for authorizing such bonds by the council, the council must order a referendum on the questions of buying or building the system. Many cities prefer to submit the questions to an election in the same manner as provided by law for tax bonds. In that way, the council feels that it has more definitely ascertained the will of the voters in the matter.

When issuing revenue bonds, the governing body of the city should be careful in determining the amount, for after bonds have once been issued against the revenue of a utility, a city does not have the power to issue any additional revenue bonds on that utility until all of the original issue has been redeemed or refunded. This provision has caused much trouble for cities with revenue bonds outstanding. For instance, a city may have originally issued $400,000 in bonds against the revenue of its water system and may have paid $385,000 of the issue, leaving a balance of $15,000 unredeemed. The governing body of the city may desire to make improvements and extensions, and there may be sufficient revenue from the water system to finance $300,000 in additional revenue bonds. However, the city cannot carry out its intentions because a previous revenue issue is still outstanding.

It may be wondered why this law should have been made, or why it has not been changed. The fact is that attempts have been made to get the law amended but as yet no one has been able to prepare a constitutional bill for this purpose. The revenue bonds now outstanding were issued and sold under the present law, and the legislature does not have the power to break a contract which has previously been entered into. A bill will be proposed in the next session, however, which would authorize cities to issue revenue bonds on a utility and later to issue second-mortgage revenue bonds before the first issue is retired.

The city of Post has followed a good procedure in financing the purchase of a privately owned water and sewer system. The voters have authorized the municipality to issue a total of $600,000 in revenue bonds. Recently the city sold $450,000 of the bonds to purchase the two systems, but their cost was only $315,000. This leaves a balance of $135,000 for improvements and extensions, and, in addition, the city may still issue $150,000 in revenue bonds as needed. These bonds will bear interest at the rate of 3 and 4½ per cent and are callable after 1958.

Although interest rates are somewhat higher when bonds have this optional feature, the author believes that this provision is worth the price.

Some of the recent issues have been authorized under an agreement by which the city will redeem the bonds after a certain date at a certain price, plus of course accrued interest and a premium.

Time Warrants

In addition to tax and revenue bonds, Texas municipalities have the authority to issue time warrants redeemable from taxes without a vote of the qualified electorate of the city. By following the provisions of Article 2368a, Vernon's Texas Statutes, cities with less than 5,000 population may issue warrants up to $7,500 in any one year; cities with 5,000 to 25,000 may issue $10,000 in warrants; those with 25,000 to 50,000, $25,000; and over 50,000, $100,000.

The importance of good management in the operation of a water system should be stressed. A few municipally owned water systems in Texas are not taking full advantage of the possibilities of tapping charges, higher rates for users outside the city limits, fire protection standby charges and payments by developers who are building new subdivisions. Every city should establish definite policies on such services.

This Month's Cover

So large that we had to back away pretty far to give you an all-inclusive view is Chicago's South District Filtration Plant, the largest plant of its type in the world. Impressive even at that distance, you'll find it still more wonderful at close range on one of the inspection tours hosted by Chicago's Engineer of Water Purification, John R. Baylis, during A.W. W.A. Conference week, May 30 to June 3. It's a feature of this year's meeting you'll not want to miss.

Cathodic Protection Design Considerations

By Raymond H. McLeod

A paper presented on Oct. 25, 1948, at the Missouri Section Meeting, Jefferson City, Mo., by Raymond H. McLeod, Field Engr., Electro Rust-Proofing Corp (N.J.), Belleville, N.J.

THE application of cathodic protection is becoming more and more important as a means of fighting corrosion on pipelines, elevated steel water tanks, refinery equipment and other metallic structures in contact with water or soil. As the corrosion of submerged metal is caused by small currents flowing from anodic to cathodic areas, cathodic protection stifles the flow of current in these local "corrosion cells" by furnishing an auxiliary current from anodes suspended in water to the tank and riser plates.

Auxiliary current is furnished by rectifiers or galvanic anodes. Rectifiers are used when power is available. They have the advantage of being easily regulated, with no moving parts, and require very little maintenance. Copper oxide and selenium stacks are the types generally used and have proved satisfactory in the field for over twelve years. Galvanic anodes of magnesium or zinc are used extensively, especially for pipeline protection. Other problems can be met with this type of anode, provided current density requirements are not too high. Galvanic magnesium anodes are quite frequently employed in domestic hot-water heaters, and most manufacturers now include this protection.

After the selection of the power source, the next problem is that of choosing anode material. It has been found that anode material should have the following properties: [1] strength, [2] a high electrochemical equivalent, [3] an even pattern of corrosion on its surface and [4] suitable shape. Some metals chosen for anode use are aluminum, steel, carbon and platinum. Galvanic anodes are usually of magnesium or zinc. In protecting elevated steel tanks, aluminum anodes have proved satisfactory with rectifiers as the power source. The aluminum is light in weight, has a high electrochemical equivalent and a uniform corroding characteristic, and competes favorably with other metals economically. Steel discolors the water around the electrode and disintegrates at the rate of approximately 20 lb. per ampere-year, as against 6.4 with aluminum. Carbon is fairly brittle, and platinum, although theoretically nonsacrificial, is expensive because of the lengths and number of platinum anodes necessary to obtain proper current distribution. For galvanic anodes, magnesium has the advantage of a higher driving potential and a higher electrochemical equivalent than zinc.

Coatings have been employed for many years as a protective measure against corrosion. They can be effectively used with cathodic protection since the exposed areas are reduced to holidays or breaks in the coating which may only represent a small percentage of the total surface. Coatings of high electrical resistance are best because they force protective currents to seek out these breaks or holidays. In the interest of lower costs of installation and operation, it is advisable to paint

the water contact areas of new tanks and riser pipes before applying cathodic protection. In old tanks, the old paint and corrosion products are useful in reducing current density demand, and repainting is rarely advised before installing cathodic protection.

In designing a cathodic protection system, the engineer must consider the factors affecting rectifier capacity and anode design: [1] the area of bare metal exposed to corrosion, [2] water quality, [3] operating conditions, [4] the configuration of the structure to be protected and [5] obstructions such as structural members present.

To elaborate briefly, water or soil analysis is important, as it reflects on the current density required for protection and anode configuration. In waters of high oxygen content, or containing other depolarizing compounds, the current density required for protection is greatly increased. The demand varies, some tanks needing only 0.5 ma. per square foot for protection, while others may need as much as 20 per square foot. It is necessary to know the resistance of the water, as this determines the number of electrodes and their spacing. A water of high electrical resistance may need electrodes spaced within 6 in. of the tank wall and 12 in. apart on the electrode circle, while in waters of low resistance one central electrode may suffice.

In designing for configuration, electrodes must be spaced so that all submerged sections of the tank are adequately protected. A riser electrode must be installed to take care of this section, because very little of the current supplied by bowl electrodes is realized in the riser sections of the tank. Also, if the tank is very large, it may be necessary to suspend additional anodes to provide protection to the bowl floor, as the wall anodes will prove insufficient for this purpose. Obstructions, such as heater or overflow pipes or structural members, need protection too and may require specially spaced electrodes.

The cost of a cathodic protection installation on a tank is comparable to the cost of one complete scraping and painting of the tank interior. Of course, once the unit is set up and maintained in operating condition, this phase of tank maintenance is eliminated. Thus, over a period of several painting cycles, the tank owner will save considerable sums in the cost of painting, as well as on depreciation of the tank, since no metal loss on submerged sections will occur. This advantage is not present if the tank is merely painted regularly, because metal loss still continues through breaks or holidays in the paint film. The tank owner also eliminates the cost and inconvenience of interruptions in tank service while painting, since cathodic protection can be installed and serviced without draining the tank.

Although the cathodic protection system requires a minimum of attention, it should be regularly checked so that continuous operation is obtained within the specified current range. As the anode material disintegrates, the resistance of the circuit is increased, requiring a simple adjustment of the transformer taps on the unit. Anode material is easily replaced after its depletion. For those tank owners who wish to have this work done for them, complete maintenance service and inspection by trained crews are available.

The proven ability of cathodic protection in reducing costly maintenance on tanks warrants a thorough investigation of the subject by all tank owners. Cathodic protection properly applied can add many years of trouble-free service to tanks.

Requirements of Cathodic Protection Systems

By Frank E. Dolson

A paper presented on Oct. 25, 1948, at the Missouri Section Meeting, Jefferson City, Mo., by Frank E. Dolson, Distr. Engr., St. Louis County Water Co., University City, Mo.

CATHODIC protection of steel water towers is a relatively recent adaptation of an old principle. Many years ago—in 1824 to be exact—Sir Humphrey Davy discovered and applied this principle for protecting underwater metal parts of ships against salt water corrosion. He utilized a zinc-copper couple for replacing the corrosion of copper by the corrosion of zinc. Some twenty years ago the need for protecting long transmission pipelines from soil corrosion became apparent, and the oil and gas industries, recognizing the economies of cathodic protection, made extensive use of it in a successful effort to prevent service interruptions.

The water works industry also accepted cathodic protection as an effective and economical method for preventing corrosion in water tanks. Perhaps because this process seemed an easy answer to a very difficult maintenance problem, many hastened to make use of it without first exercising prudent engineering precautions. As a result, many cathodic protection systems were purchased which provided either partial protection or none at all. Some of the initial systems were underdesigned with inadequate rectifier capacity, while others were sold with one of the necessary parts missing.

Obviously there is no economy in purchasing a system that does only a portion of the job. No doubt many water superintendents and operators have asked themselves questions such as: Do I need cathodic protection? Is it economical? How can I tell whether it is doing the job? The following discussion will be of some value in answering these questions.

Corrosion of Steel

The surface of steel in contact with soil or water tends to become either anodic or cathodic. For example, a new section of steel pipe connected to an old section of badly corroded pipe may immediately become anodic to the old section. A rusty piece of steel and a bright piece of steel placed in water and connected together with an external wire will form a corrosion couple. The bright piece of steel will be anodic to the rusty piece. So it is in a water tank. In a new, unpainted tank, the mill scale coating on the steel will be cathodic to bright sections of metal through exposed holidays in the mill scale; there will be a vast cathodic area and many small anodic areas. In a corrosive water this would be conducive to rapid, localized corrosion. Abrasions of the metal surface caused, for example, by movement of ice would result in these areas being anodic to

all the tubercles that may have formed on the inner surface of the tank. The current in instances such as outlined above would flow from the bright metal through the water to the rusty metal and then complete its circuit through the sides of the tank.

The principle of the common dry cell is an excellent analogy for describing the corrosion process. Everyone is familiar with the uses of this very necessary piece of equipment and its principle is well known. A dry cell consists of three essential parts: a carbon cathode, a zinc anode and the intervening electrolyte. The carbon cathode is marked "plus" and the zinc anode is marked "minus," which conforms to the accepted practice in determining the direction of current flow. When a resistance load is connected across these two terminals, current flows from the positive terminal through the load to the negative terminal, which is the outer zinc shell of the battery. From the zinc terminal, current flows through the electrolyte to the carbon cathode, completing the circuit. The zinc in this cell is an anode and progressively deteriorates as the battery is used. The current flow in the external circuit is from the carbon to the zinc. In the internal circuit the flow of current is from the zinc to the carbon, or from the anode to the cathode.

Corrosion of a steel water tank can be compared to a dry cell. In the tank a great many of these little batteries are formed, each one generating a small voltage. Each one is causing minute quantities of current flow and each, with an adequate oxygen supply, is causing corrosion.

Cathodic protection, in effect, simply superimposes another current upon these little battery cells. It has been found that when current entering the corroding area is sufficiently strong to counterbalance the current of these many battery cells, corrosion will cease. Current from the cathodic protection system must be equal to or greater than the current leaving the many corroding or anodic areas.

Current Density Requirements

Now comes the problem of how to determine the current density—that is, the current per square foot of tank—required to prevent corrosion. The component parts of a cathodic protection system consist of: [1] a source of power—generally a full-wave rectifier connected to a multiple-tap transformer; [2] an anode system; [3] necessary electrical wiring to connect the anode system to the rectifier; [4] an electrolyte; [5] the metal surface to be protected; and [6] an electrical path to return the current from the protected metal to the rectifier.

In operation, current flows from the rectifier unit to the anode system and then through the water or electrolyte to the metal surface. In tanks, the circuit is completed by using the tank as a conductor to return the current to the rectifier.

The total current required to prevent corrosion in the tank is difficult to determine. If the entire tank were bare, it would be an easy matter to determine experimentally in a laboratory the current density necessary to prevent corrosion in a test piece. Then, knowing the total area of the interior surface of the tank, it would be simple to determine the capacity of the rectifier. The voltage requirement on the rectifier could likewise be determined if the various resistances involved were known. In the field, how-

ever, it is not quite so easy since most tanks have either a coating of paint or some other protective covering or else the surface is at least partially covered with rust. The surface of the steel effectively insulated from the water does not need cathodic protection. Usually tubercles and rust have formed the cathodic portion of a local-action cell and therefore are not initially in need of protection. The areas to be protected are simply those areas that are anodic.

In a bare steel tank, assuming that a current density of 2 ma. per square foot would stop corrosion, a rectifier capacity of 2 amp. would be required for each 1,000 sq.ft. of metal surface to be protected. However, if this metal surface had originally been painted or covered with a protective coating of adequate insulating value, it is quite possible that 75 per cent of the metal would not require protection. The protection of the entire surface could then be obtained by providing 0.5 amp., or one-fourth of that required to protect 1,000 sq.ft. of bare metal.

It would seem, therefore, that in designing the cathodic protection unit there are three major unknowns: [1] the current density required to protect the metal against corrosion by a particular water; [2] the amount of surface to be protected—that is, the entire area minus that portion which is effectively coated; and [3] the distribution of the protecting current. The first unknown can be readily obtained in the laboratory by a simple experiment. The second and third unknowns can be found only in the field, by measuring the voltage effect of the rectifier at the surface of the corroding metal. Generally, this is done by measuring the voltage difference between the metal and water.

Cathodic Protection Installation

It will be helpful to describe a cathodic protection installation which was made on a 250,000-gal. elevated water tank. Constructed in 1934, the tank is 40 ft. in diameter and 85 ft. high, with a water depth of 29 ft. in the elevated bowl and a riser pipe 5 ft. in diameter and 55 ft. high. The tank mill scale was undisturbed until after erection. The surface of the steel was then cleaned by scraping and brushing, after which two coats of red lead were applied. A cathodic protection installation was installed in this tank in 1940. The original cathodic protection system consisted of a 2-amp. rectifier and three $\frac{3}{8}$-in. anodes. The rectifier was later replaced by a 3-amp., 27-v. unit, and an additional anode was installed in the riser pipe. The current output was distributed in the proportion of 1.75 amp. to the tank and 0.75 amp. to the riser pipe. The current densities were 0.46 and 0.86 ma. per square foot to the tank and riser, respectively, based on the assumption that the entire surface was bare. The voltage setting was approximately 8–10 v., and the water resistance was 3,900 ohms per milliliter. The indicated resistance of the entire circuit was approximately 3.3 ohms.

In an effort to determine the effectiveness of this installation, a series of voltage readings were obtained. At the time of test one of the three anode rods was damaged to the extent that only approximately 5 ft. of the rod was in contact with the water. The other rods were in good condition although misshapen. A copper sulfate electrode

was lowered into the water opposite an anode and very close to the water surface. The electrode was equipped with spacers in order to keep it within 1 in. of the metal surface. A potentiometer was then connected between the tank and the copper sulfate electrode. With the rectifier turned off, a reading of approximately 0.45 v. was obtained. When the rectifier was turned on, the reading was approximately 0.55 v. In other words, the metal was rendered 0.1 v. more negative by the use of this cathodic protection installation. A series of voltage readings was then obtained at various locations along the tank surface directly below the original test, each reading giving the same result. No attempt was made to obtain similar readings in the riser pipe.

The inference from these readings would be that the metal in this tank was receiving only partial protection against corrosion. The question then arises, what voltage reading is required to indicate full cathodic protection? A safe criterion to follow is 0.3 v., since the voltage generated by the many corrosion cells existing on the tank surface is generally considerably less than this figure.

The problem of current distribution from a cathodic protection installation can be determined very easily by using voltage readings. Consider for a moment a steel tank that is perfectly insulated from the water with a good electrical coating. This tank does not need cathodic protection because the steel is not in contact with the water.

Now consider that 1 sq.ft. of this tank was scraped down to bare metal and exposed to corrosion. It would then be necessary to provide only the current required to protect 1 sq.ft. of metal. As the coating on a tank deteriorates, breaks or holidays occur. The number and distribution of such breaks is unknown, and no amount of laboratory work can reveal the interior condition of a specific tank. It is possible, however, by the use of voltage readings, to determine the current distribution after a cathodic protection installation has been installed.

To be absolutely accurate, the method outlined above should be corrected for a voltage drop due to the resistance of the water and metal coating. For practical purposes, however, it will indicate whether or not the cathodic protection system is effective.

Intensive Aeration of Water

By Nils K. G. Westberg

A contribution to the Journal by Nils K. G. Westberg, Chief Chemist, Water Works, Stockholm, Sweden.

IN water treatment practice, aeration is employed for various purposes. By this process it is possible to remove totally or partially volatile compounds imparting troublesome tastes and odors to a water. These substances may be inorganic—hydrogen sulfide, for example—or organic, such as the conversion products from phytoplankton or other compounds causing mossy or marshy odors and tastes. Sometimes it is of great importance to reduce the carbon dioxide content of a water, which is often most simply achieved by aeration. The aeration of water containing iron and manganese is a condition for the oxidation of the metal ions to the trivalent stage, preceding the precipitation of the oxide hydrates. The activated-sludge process in the purification of sewage is based upon the vigorous aeration of the water in special basins.

A great number of different aeration methods are found in common practice. Drop aerators, often used at old purifications plants treating well water containing iron and manganese, are well known. Nowadays spray nozzles, cascades, compressed-air diffusers, and various other processes are usually employed. Modern activated-sludge plants as a rule are equipped with diffusers in the form of porous plates for the dispersion of the compressed air in the water. The aims, principles and methods of aeration are discussed in detail in the literature (1–3).

Design Features

During the last ten years a new aeration method has been established in Sweden. This device, which has been employed for all common purposes, is called the Inka aerator.* Its principal features are evident in Fig. 1. A plate of stainless steel, perforated in a special manner, is placed horizontally on a foundation consisting of a concrete chamber. The water is uniformly distributed over the plate by a sprinkle pipe, flowing in the direction shown by the arrow. To stabilize the bubble layer, a foam screen is placed at the discharge end of the plate, and the water is drawn off at a weir. Air is blown into the concrete chamber by a fan, passes through the perforated plate and the water, and is carried off by an exhaust stack. Thus, the direction of the air is at right angles to the flow of the water. If the number, size and location of the plate holes are appropriately chosen in relation to the flow of water and air, the body of the water is distributed in a

* Made by Industrikemiska A.-B., Regeringsgatan 109, Stockholm, Sweden. American representative, A. Johnson & Co., Inc., New York.

continuous layer of almost uniform, polyhedral bubbles (Fig. 2).

The distribution of the water in an enormous number of bubbles, the walls of which consist of thin water films, is of great importance for the intensity of the gas exchange. It is known that the exchange between a gas and liquid is chiefly determined by the diffusion in the liquid phase and in the boundary surface between the two phases. Furthermore, the water films of the bubble layer are constantly renewed, experimental investigations having given evidence of a continuous vertical transport of water. This is of special significance, since the water films thus consist of streaming water. The diffusion of the gases under such favorable conditions is fairly rapid.

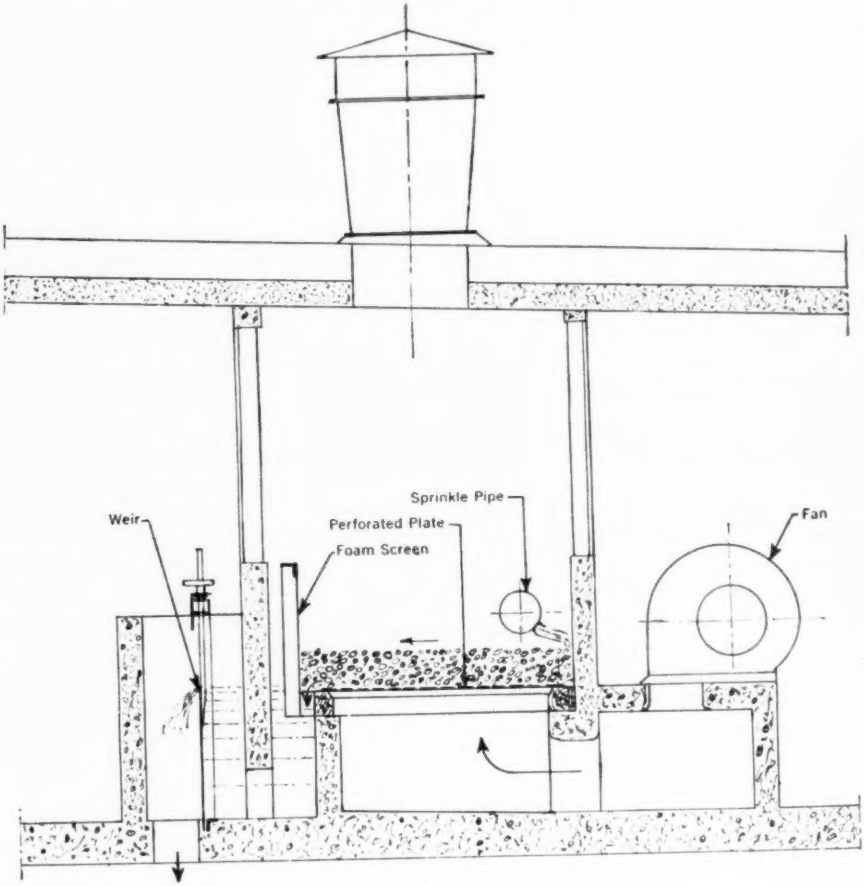

Fig. 1. Inka Aerator

Figure 3 shows an actual installation. This aerator is made in four

parts, and the bubble layer is seen as a white scum. Along the side walls are the sprinkle pipes, and in the middle the foam screens can be observed. The wheels in the center are for regulating the weirs. In the rear is the air fan. The aerator has windows on three sides and the concrete walls are lined with glazed brick.

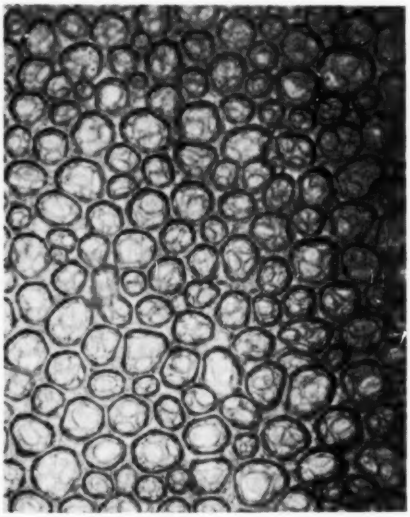

FIG. 2. Water Bubble Layer

The use of a fan is an inexpensive way of supplying air in comparison with methods requiring air compressors. The leading feature of this aerator, however, is the extremely great quantity of air employed. In plants for the removal of iron and manganese, the amount of air is generally only a few per cent by volume of the water. Activated-sludge plants require ample quantities of oxygen and generally consume 5–10 volumes of air per volume of water. In an Inka aerator the air-water ratio normally is between 30:1 and 300:1, according to the desired effect. Because of the very vigorous aeration obtained, this method is called "intensive aeration" in Sweden. From an economic point of view, the great air quantities are reasonable, since the loss of head due to the passage of the air through the plate and water is quite inconsiderable, amounting to approximately 0.1 psi. The total head loss of water in the conduits and at

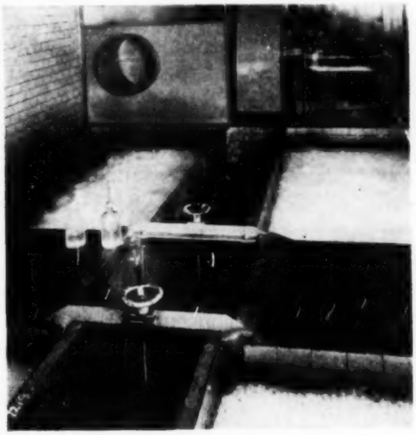

FIG. 3. Aerator Installation

the weirs also is moderate, seldom exceeding 0.7 psi.

Effectiveness of Aeration

If the assumption is made that the gas exchange between air and water by the thorough vertical mixing goes far enough to establish an equilibrium between the oxygen content of the air and of the water, the effect of aeration may be calculated from the following equations:

$$\frac{b_x}{a_x} = R \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$W(db_x) = \frac{A(dx)}{l}(a - a_x) \ldots (2)$$

in which l is the length of the aerator, W is the rate of water supplied, A is the rate of air supplied, a is the oxygen content of the air supplied, a_x is the oxygen content of air escaping at x distance from the inlet, b is the oxygen content of the water before aeration, b_x is the oxygen content of the water at x distance from the inlet and R is the equilibrium ratio of the oxygen content of the water to that of the air. The oxygen content, b_1, of the aerated water is:

$$b_1 = Ra - (Ra - b)e^{-A/RW} \quad (3)$$

The aeration effect of a given aerator obviously is determined by the ratio of air and water flow. If the purpose of aeration is to remove gases—for instance, carbon dioxide—Eq. 3 is still valid; the notations b_1, a and b then signify the concentrations of carbon dioxide, and R the corresponding equilibrium ratio.

Practically, the dimensions and working conditions of an Inka aerator must be founded on an empirical basis. Experimental data do not agree with theoretical calculations, since in reality the equilibrium of the gas exchange is not attained. Experience now makes it possible to construct Inka aerators which will meet previously stipulated requirements concerning the increase of the oxygen content or the reduction of the carbon dioxide content of the water. Further important questions of working practice involve the suitable water flow per unit of length and the appropriate amount of air per unit of area of the perforated plate. Correct values must be chosen, as otherwise an even and stable bubble layer is not obtained.

Carbon Dioxide Removal

Although the essential features of the function and applicability of the aerator have already been illustrated, a more detailed discussion of the removal of carbon dioxide in hard and moderately hard waters may be of interest. In this field the aerator has met with particular success in Sweden. The aim of aeration under these conditions is often to render the water scale-forming—that is, to adjust the water to its calcium carbonate saturation point. By the addition of lime, sodium carbonate or caustic soda, it is always possible to transfer the carbon dioxide into hydrocarbonates, thereby bringing the water to such a composition that it is saturated (or oversaturated) with calcium carbonate. Likewise, hard or moderately hard waters may be brought to the saturation point by aeration. At the saturation point the composition of the water is determined by the equilibrium equations:

$$[H^+][HCO_3^-] = k_1[CO_2] \quad (4)$$

$$[H^+][CO_3^{--}] = k_2[HCO_3^-] \quad (5)$$

$$[Ca^{++}][CO_3^{--}] = k_s \quad (6)$$

k_1 and k_2 denoting the dissociation constants of carbon dioxide and k_s the solubility product of calcium carbonate. From Eq. 4–6, two important expressions are easily obtained:

$$[CO_2] = \frac{k_2}{k_1 k_s} \cdot [Ca^{++}][HCO_3^-]^2 \quad (7)$$

$$[H^+] = \frac{k_2}{k_s}[Ca^{++}][HCO_3^-] \quad (8)$$

Equations 7 and 8 prove that every water at the saturation point contains a certain amount of carbon dioxide and

shows a definite pH value. The amount of carbon dioxide at the saturation point in soft waters is extremely small and analytically not determinable. For that reason, in the United States Eq. 8 is of principal interest. Equation 7 is particularly important for the aeration of moderately hard and hard waters. It determines the maximum content of carbon dioxide which should be left in the water after aeration. All of these equations and expressions have been discussed in considerable detail by a great number of authors (see the article by Langelier (4) and the references therein).

Calculation will often show that it is most economical to adjust the water composition to the saturation point by the addition of lime. Although this method is frequently the best one, its inconvenience, due to the increase in water hardness and the necessity of permanent control, may give the preference to aeration. Some water plants treating soft waters, in order to avoid combining aeration with the addition of lime, pass the aerated water through filters containing alkaline filter media ("magno"). The supervision necessary for such a combination plant is inconsiderable.

As the corrosion of certain metals in water is accelerated by high oxygen contents, intensive aeration may constitute a disadvantage. Larson and Buswell (5) have stated: "From the standpoint of corrosion prevention the disadvantage of introducing excessive dissolved oxygen may overcome the advantage of calcium carbonate supersaturation. This would be particularly true at dead ends of low circulation." This fact should be kept in mind especially in dealing with very soft waters, the scale-forming capability of which is doubtful.

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Pipeline Network Flow Analysis Using Ordinary Algebra

By Malcolm S. McIlroy

A contribution to the Journal by Malcolm S. McIlroy, Prof. of Elec. Eng., Cornell University, Ithaca, N.Y.

THE method presented in this paper for determining the values of flows and friction head losses in pipeline networks has an inherent advantage for use in networks with a small number of loops. Like the relaxation or Hardy Cross method (1), the procedure involves successive approximations which determine corrections in flow rates in the network loops. However, since these corrections are found with due regard for the restrictions imposed on changes of flows and head losses by the complete configuration of the network, convergence is often achieved in one approximation step, and should rarely require more than two successive approximations. Each successive step involves the solution of a set of simultaneous linear algebraic equations equal in number to the number of effective loops in the network. The procedure is illustrated by a numerical example applying to a three-loop network.

Initial Assumptions

Figure 1 is a schematic diagram of a pipeline network having considerable generality. The network contains two distribution loops, *b* and *c*, which deliver fluid to six known loads; two trunk supply mains, 1 and 9; and two sources of flow, between which is maintained a known difference of head, H'. A third effective loop, *a*, is required in the analysis to account for the effect of the source head difference, H'.

For each pipeline in the network, the rate of flow, Q, and the loss of head, H, caused by fluid friction are usually considered to be related by an expression of the form:

$$H = k_pQ^n \dots\dots\dots\dots (1)$$

in which n is a constant, often taken as 1.85, and k_p is a constant whose value depends on the dimensions and condition of the pipeline. The constant k_p is hereafter called the head loss coefficient of a pipeline. Given values of k_p for the pipelines of Fig. 1 are listed on line 5 of Table 1.

The first step in the analysis of a network is to assign guessed values of flows and head losses to all its pipelines in a manner which balances the network both with respect to flows and to head losses. These guessed values are chosen with reasonable attention to the given values of head loss coefficients, k_p, so that the initial values, k_0, of the coefficients lie within a range of about 40 to 200 per cent of the corresponding correct values, k_p. In Fig. 1, the assumed values of head loss, H_0, are underlined, and the assumed values of flow, Q_0, are shown at the tails of the flow arrows. These values of H_0 and

Q_0 are listed on lines 1 and 2, respectively, of Table 1. The corresponding values of k_0 given on line 4 of Table 1 for $n = 1.85$ are found from the relation:

$$k_0 = \frac{H_0}{Q_0^n} \quad \ldots\ldots\ldots (2)$$

Computation of Flow Corrections

The assumed flows and head losses must be so adjusted that the incorrect values, k_0, of head loss coefficients will be converted to their correct values, k_p. The following treatment explains the procedure for accomplishing this adjustment. The fundamental principle involved is that a change in head loss in a pipeline varies very nearly in proportion to the corresponding change in flow rate, provided the change in flow is not large compared with the total flow.

Since all flow corrections in the network should be governed by the necessary changes in values of head loss coefficients, the next step is to compute the values of the correction factors, α_0, by which the incorrect coefficients, k_0, must be multiplied to obtain the desired coefficients, k_p. Values of this factor:

$$\alpha_0 = \frac{k_p}{k_0} \quad \ldots\ldots\ldots\ldots (3)$$

are given for all pipelines on line 6 of Table 1. If all the coefficients are to be corrected to new values, $k_p = \alpha_0 k_0$, the flows and head losses for all pipelines must change to correspond to the corrected coefficients. Let H_1 and ΔQ represent, respectively, the corrected head loss and change in flow in any pipeline which result from changing the head loss coefficients throughout the network. The value of the revised head loss is then, from Eq. 1:

$$H_1 = \alpha_0 k_0 (Q_0 + \Delta Q)^n \quad \ldots\ldots (4)$$

Taking the first two terms of the bi-

TABLE 1

Values Corresponding to n = *1.85*

Table Line Number	Quantity	Pipeline Number								
		1	2	3	4	5	6	7	8	9
1	H_0	15	8	5	6	7	20	35	10	28
2	Q_0	21	4	8	3	11	10	3	1	15
3	Q_0^n	280	13	46.9	7.63	84.4	71	7.63	1	150
4	$k_0 = \frac{H_0}{Q_0^n}$	0.0535	0.615	0.107	0.785	0.083	0.282	4.59	10	0.187
5	k_p	0.028	0.35	0.13	0.39	0.05	0.50	7.0	5	0.15
6	$\alpha_0 = \frac{k_p}{k_0}$	0.524	0.569	1.22	0.496	0.603	1.77	1.53	0.5	0.802
7	$R_0 = \frac{H_0}{Q_0}$	0.715	2.0	0.625	2.0	0.636	2.0	11.7	10	1.87
8	$\alpha_0 R_0$	0.374	1.14	0.763	0.992	0.384	3.54	17.9	5	1.50
9	$\lvert\alpha_0 H_0\rvert$	7.85	4.55	6.1	2.98	4.22	35.4	53.6	5	22.5
10	ΔQ	2.19	0.75	−0.97	1.44	1.44	−1.72	−0.47	0.47	−2.19
11	$n\Delta Q$	4.05	1.39	−1.79	2.66	2.66	−3.18	−0.86	0.86	−4.05
12	$Q_0 + n\Delta Q$	25.05	5.39	6.21	5.66	13.66	6.82	2.14	1.86	10.95
13	H_1 (Eq. 7)	9.4	6.14	4.75	5.61	5.24	24.1	38.3	9.30	16.4
14	$Q_1 = Q_0 + \Delta Q$	23.2	4.75	7.03	4.44	12.44	8.28	2.53	1.47	12.81
15	Q_1^n	333	17.9	37	15.8	106	49.6	5.56	2.04	112
16	$k_1 = \frac{H_1}{Q_1^n}$	0.0282	0.343	0.128	0.355	0.0494	0.486	6.88	4.55	0.146

nomial expansion indicated in Eq. 4, one obtains as a first approximation:

$$H_1 \approx \alpha_0 k_0 (Q_0^n + nQ_0^{n-1}\Delta Q) \quad \text{..(5)}$$

Define the *original resistance*, R_0, of each pipeline as the ratio of the original head loss to original flow:

$$R_0 = \frac{H_0}{Q_0} = k_0 Q_0^{n-1} \quad \text{......(6)}$$

Substitute Eq. 6 in Eq. 5 to obtain:

$$H_1 \approx \alpha_0 R_0 (Q_0 + n\Delta Q) \quad \text{....(7)}$$

network contained no loops other than loop a, the magnitude of ΔQ would be the same for all pipelines, and one could solve immediately for its value. However, it is more important to consider the general problem of a network containing l loops.

If Eq. 7 is applied to all the pipelines in an l-loop network, subject to the restrictions imposed by the network arrangement, it can be shown (2) that the head loss relations may be expressed by a set of simultaneous linear algebraic

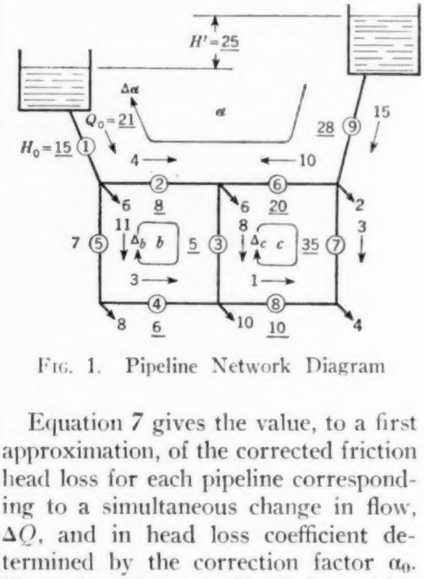

FIG. 1. Pipeline Network Diagram

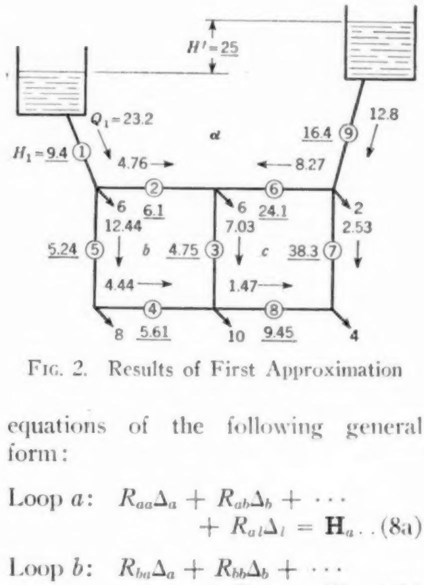

FIG. 2. Results of First Approximation

Equation 7 gives the value, to a first approximation, of the corrected friction head loss for each pipeline corresponding to a simultaneous change in flow, ΔQ, and in head loss coefficient determined by the correction factor α_0. The value of ΔQ in Eq. 7 is positive when it increases the magnitude of the original flow, Q_0, and is negative when it decreases the flow. To use Eq. 7 in analyzing a network, one recognizes that the values of H_1 for all the pipelines bounding any loop should be in balance. For example, in loop a of Fig. 1, the sum of the values of H_1 for pipelines 9 and 6 must equal the head difference, H', plus the sum of the values of H_1 for pipelines 1 and 2. If the

equations of the following general form:

$$\text{Loop } a\text{:} \quad R_{aa}\Delta_a + R_{ab}\Delta_b + \cdots + R_{al}\Delta_l = \mathbf{H}_a \quad \text{..(8a)}$$

$$\text{Loop } b\text{:} \quad R_{ba}\Delta_a + R_{bb}\Delta_b + \cdots + R_{bl}\Delta_l = \mathbf{H}_b \quad \text{..(8b)}$$

$$\cdot \quad \cdot \quad \cdot$$

$$\text{Loop } l\text{:} \quad R_{la}\Delta_a + R_{lb}\Delta_b + \cdots + R_{ll}\Delta_l = \mathbf{H}_l \quad \text{..(8c)}$$

In Eq. 8, the flow corrections, Δ_a, Δ_b, . . . Δ_l, are the unknowns. They are the changes in flow which occur in the loops indicated by the respective subscripts. For convenience, it is recommended that they be called positive in the clockwise direction in all loops, as

shown in Fig. 1. The change of flow, ΔQ, in any individual pipeline is the resultant, with proper regard for sign, of the flow changes in the loops which it bounds. Each right-hand member, $\mathbf{H}_a, \mathbf{H}_b, \ldots \mathbf{H}_l$, in Eq. 8 represents an influence tending to cause a positive or clockwise change in flow in each loop. Its value for loop l is:

$$\mathbf{H}_l \doteq \frac{1}{n}(H_l' - \Sigma \alpha_0 H_0) \quad \ldots (9)$$

in which H_l' represents the head difference, if any, maintained between two sources bounding loop l, taken positive when that difference tends to cause a positive or clockwise flow; and $\Sigma \alpha_0 H_0$ is the sum of the products of the correction factors, α_0, and the original head losses, H_0, for the pipelines bounding loop l. All head losses H_0 are taken positive when in the assumed positive direction of loop flow change, Δ_l, and negative when oppositely directed. For the present example, magnitudes of $\alpha_0 H_0$ are given on line 9 of Table 1. The evaluation of the $\mathbf{H}$ terms is carried out in Table 2, from Eq. 9, with the following results:

TABLE 2

Evaluation of **H** *Terms*

	Loop		
	a	*b*	*c*
	Values of $\alpha_0 H_0$		
Positive (clockwise)	22.5 35.4	4.55 6.1	53.6
	57.9	10.65	53.6
Negative (counter-clockwise)	7.85 4.55	2.98 4.22	35.4 6.1 5.0
	12.4	7.20	46.5
$\Sigma \alpha_0 H_0$ H'	45.5 25	3.45	7.1
$H' - \Sigma \alpha_0 H_0$ **H**	−20.5 −11.05	−3.45 −1.86	−7.1 −3.83

$$\mathbf{H}_a = -\ 11.05 \text{ head units} \quad \ldots (10a)$$

$$\mathbf{H}_b = -\ 1.86 \text{ head units} \quad \ldots (10b)$$

$$\mathbf{H}_c = -\ 3.83 \text{ head units} \quad \ldots (10c)$$

The R coefficients in Eq. 8 are of two general types. For each loop, the *self-resistance*, $R_{aa}, R_{bb}, \ldots R_{ll}$, is the arithmetic sum of the $\alpha_0 R_0$ products for the pipelines bounding the loop. These products, given on line 8 of Table 1, are added here for the present example:

R_{aa} (pipelines 1, 2, 6, 9)
$$= 0.37 + 1.14 + 3.54 + 1.50 = 6.55 \quad \ldots (11a)$$

R_{bb} (pipelines 2, 3, 4, 5)
$$= 1.14 + 0.763 + 0.992 + 0.384 = 3.28 \quad \ldots (11b)$$

R_{cc} (pipelines 6, 7, 8, 3)
$$= 3.54 + 17.9 + 5.0 + 0.76 = 27.2 \quad \ldots (11c)$$

The *mutual resistance*, such as R_{ab}, for any pair of loops is the negative of the value of the product $\alpha_0 R_0$ for the pipeline common to the two loops identified by the subscripts. The negative sign occurs in the usual situation where the positive flow changes in the two loops oppose each other in the common pipeline. If the loop flow changes are both in the same direction in any pipeline, the mutual resistance for the two loops is positive. Whenever two loops have no pipeline in common, the value of their mutual resistance is zero. Val-

ues of mutual resistance in the present example, taken from line 8 of Table 1, are:

$$R_{ab} = R_{ba} = -1.14 \quad \text{(12a)}$$

$$R_{bc} = R_{cb} = -0.763 \quad \text{(12b)}$$

$$R_{ac} = R_{ca} = -3.54 \quad \text{(12c)}$$

The literal constants in Eq. 8 are now replaced by their numerical values to give the simultaneous equations:

$$6.55\Delta_a - 1.14\Delta_b - 3.54\Delta_c = -11.05 \quad \text{(13a)}$$

$$-1.14\Delta_a + 3.28\Delta_b - 0.763\Delta_c = -1.86 \quad \text{(13b)}$$

$$-3.54\Delta_a - 0.763\Delta_b + 27.2\Delta_c = -3.83 \quad \text{(13c)}$$

The roots of Eq. 13 are:

$$\Delta_a = -2.19 \text{ flow units} \quad \text{(14a)}$$

$$\Delta_b = -1.44 \text{ flow units} \quad \text{(14b)}$$

$$\Delta_c = -0.47 \text{ flow unit} \quad \text{(14c)}$$

Values of actual flow changes ΔQ in all the pipelines are found by appropriate algebraic addition of the pertinent loop flow changes. For example, in pipeline 3 positive flow change Δ_b is in the direction of original flow Q_0, and positive flow change Δ_c opposes the original flow. Hence the value of ΔQ is $\Delta_b - \Delta_c$, or -0.97 flow unit, as shown on line 10 of Table 1. After all entries on line 10 have been made, their accuracy should be checked by completing line 14 to find the values of corrected flow rates, Q_1. These new flows are then inserted on a diagram showing results of the solution, as in Fig. 2. The flows must be in balance at every network junction.

The final step in the first approximation is to carry out the operations indicated on lines 11, 12 and 13 of Table 1. The corrected head losses, H_1, from line 13 are then entered in Fig. 2, and are inherently in balance if the computations have been correctly made. If a slide rule is used for calculations, it may be necessary to adjust the values of H_1 very slightly before they are inserted in Fig. 2 to show an exact balance of head losses.

TABLE 3

Comparison of Values After First-Approximation Solution With Original Guesses and Desired Head Loss Coefficients

Pipeline	H_0	H_1	Q_0	Q_1	k_0	k_1	k_p
1	15	9.4	21	23.2	0.0535	0.0282	0.028
2	8	6.14	4	4.76	0.615	0.343	0.35
3	5	4.75	8	7.03	0.107	0.128	0.13
4	6	5.61	3	4.44	0.785	0.355	0.39
5	7	5.24	11	12.44	0.083	0.0494	0.05
6	20	24.1	10	8.28	0.282	0.486	0.50
7	35	38.3	3	2.53	4.59	6.88	7.00
8	10	9.45	1	1.47	10	4.55	5.00
9	28	16.4	15	12.81	0.187	0.146	0.15

Check on Accuracy

The accuracy of the entire solution is tested by computing the values of head loss coefficients, k_1, which corre-

spond to the corrected flow rates, Q_1, and head losses, H_1, as shown on line 16 of Table 1. The results of this first-approximation solution for the present example are given in Table 3. The last two columns of Table 3 compare the values of k_1 and k_p and show a striking improvement in the values of the head loss coefficients from their original values, k_0. Original values of coefficients lying in the range of approximately 50 to 177 per cent of their correct values, as shown on line 6 of Table 1, are improved so greatly that seven of the nine coefficients have only trivial errors, and the two which are significantly incorrect have errors of approximately 10 per cent. Most engineers would consider this solution satisfactory, but if even better precision is required, a second solution based on the results of the first would give almost perfect values of all quantities.

The error in head loss determined by the linear approximation for any pipeline does not depend on the percentage error in the value of its original coefficient, except as the coefficient error contributes to the entire readjustment of network flows. The error depends largely on the ratio of the flow change, ΔQ, to the original flow, Q_0, in the pipeline. The head loss error resulting from the linear approximation is plotted as a function of the ratio $\Delta Q/Q_0$ in Fig. 3. This usually small inherent error is always negative; that is, it indicates head losses slightly lower on the average than they should be. A simple method of compensating for this slight bias in the results is to raise all values of α_0 by a small amount, such as 3 per cent, before entering them in Table 1. The head losses found from the solution will still be in balance, but the coefficients will be randomly distributed about their correct values.

Advantages and Disadvantages

The method of analysis of pipeline networks described above has two advantages. One is that the simultaneous effect of all pipelines in the network is considered in the solution. Hence, the flow changes found for the various loops do not overcorrect significantly

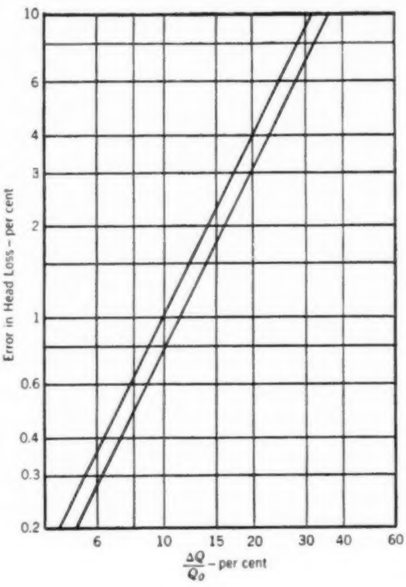

FIG. 3. Error in Head Loss Approximation

between successive steps, and rapid convergence results. The second advantage follows from the first. For a given set of original guesses of flow rates, the same degree of accuracy in the result is obtained in fewer actual computational steps compared with the relaxation method, as found in several actual comparisons. The saving in total work increases as the number of

loops increases. The number of computations per successive approximation is greater than in the relaxation method, but fewer successive approximations are required, and usually one should be sufficient.

The principal disadvantage of the method is the requirement of solving the simultaneous equations. The writer uses a set of generalized solutions for the roots of the equations for networks of one to four loops. Literal solutions for the roots of equations for networks having more loops could, of course, be derived. Solutions by determinants may be used, or machine methods may be employed for studies of large networks. Another interesting method of solving simultaneous equations has been published (3). It is probable that most engineers will limit their use of this linear-approximation method to the analysis of networks containing only a few loops.

In common with any successive-approximation method, the procedure described here involves the sometimes troublesome operation of making reasonably good original guesses, and it has a similar, though less serious, difficulty in convergence when a pipeline carrying a small flow is subject to relatively large flow changes because of its proximity to pipelines carrying large flows.

Conclusion

The linear-approximation method is well adapted to the analysis of flows and head losses in networks containing a few loops. Convergence is certain and rapid, and the number of computational operations required is less than that needed in the relaxation method to give the same degree of accuracy from the same original guesses of flow rates. Since the method involves relatively little repetition of identical operations, it is not tedious to use.

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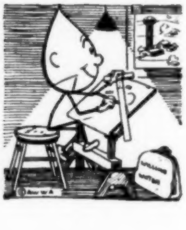

Maintenance and Operating Problems of Winnipeg

By N. S. Bubbis

A paper presented on Sept. 1, 1948, at the Minnesota Section Meeting, Winnipeg, Man., by N. S. Bubbis, Acting Gen. Mgr., Greater Winnipeg Water Dist., Winnipeg, Man.

WINNIPEG, Man., is located at the junction of the Red and Assiniboine Rivers. The city is now using its third source of water supply. The first system, which took water from the Assiniboine River, was installed in 1880 and operated by the Winnipeg Water Works Co., a private concern. In 1899 the city purchased the plant, thus making it a municipally owned and operated utility. The following year the source of supply was changed to artesian wells.

By 1906 it was evident that this well supply would not be adequate, and engineering boards were set up to investigate new sources. These studies finally led to the incorporation of the Greater Winnipeg Water Dist. and the building of an aqueduct, 96½ miles long, which brought water into the city from Shoal Lake, the western arm of the Lake of the Woods. This water flows by gravity to the reservoirs from which high-lift pumps deliver it directly into the system.

The domestic distribution system consists of 328 miles of mains, ranging in diameter from 3 to 42 in., which are mostly cast iron, but also include cement asbestos, reinforced concrete and concrete-covered steel pipe. There are over 50,000 services, nearly all metered, made of lead, copper or cast iron; 2,919 hydrants, 2,421 of which have control valves; and 3,361 main valves in the system.

In addition to this domestic system, which operates at 75-psi. pressure, the city also has a separate, high-pressure system which can pump water at pressures up to 300 psi. for fire-fighting purposes. There are 12.8 miles of cast-iron mains and 161 hydrants in this system.

Water Mains

The climatic and soil conditions in the Winnipeg area make the maintenance of water mains very difficult. The soil in Winnipeg is a lacustrine and alluvial silt overlying glacial till. It had its origin in the grinding and pulverizing of limestone rock areas lying immediately to the north and was formed by the southward moving glaciers of the ice age.

The soluble salts originally present in the limestone have crystallized in pockets and stringers in the clay just beneath the surface soil. The salts usually encountered in excavating include the sulfates of sodium, magnesium and calcium, which are objectionable because of their relatively high corrosive action.

Corrosion cells are set up on the underground pipe when the ground water dissolves the salts present in the soil, the solution acting as an electrolyte in conjunction with the metallic constituents of the pipe walls and fittings. The resultant corrosion is an electrochemical process induced by galvanic action which produces graphitization of cast iron. This form of corrosion causes the greatest trouble in the Winnipeg area. Usually the life of the cast-iron pipe is not much more than 40 years, after which the pipe becomes so soft and the leaks so frequent that it has to be renewed.

On the average, approximately 180 main breaks are repaired each year, a very high figure for a system of this size. Centrifugally cast cast-iron pipe, which the city began to install in 1925, appears to suffer from the corrosive soil conditions somewhat in the same fashion as does the pit-cast pipe. Signs of very bad corrosion have also occurred in cast-iron pipe manufactured locally after being in service for a ten-year period.

In 1932, as a result of a considerable amount of study and experimentation, it was decided to install some asbestos-cement pipe. The first main was 18 in. in diameter and was laid in a location adjacent to a Winnipeg Electric Co. substation, where the soil was known to be extremely active. This pipe was very carefully observed. It was examined after six years of service and again in the fall of 1946, when thorough tests were made in conjunction with the Johns-Manville Co. and the Pitometer Co. These tests showed that after fifteen years of service there was no visible sign of any deterioration. The pipe, couplings and gaskets were apparently in as good condition as the day they were laid, and the Hazen-Williams flow coefficient was 140. The conclusion has therefore been reached that asbestos-cement pipe appears to be more suitable than cast-iron for local conditions, and a policy has been adopted of renewing all mains and installing a good number of new mains with asbestos-cement pipe.

To prevent the mains from freezing, a minimum of 7½ ft. of cover is specified, since a frost penetration of more than 7 ft. is not uncommon. It is apparent that locating and repairing main breaks under the severe winter conditions, with such a depth of frost, is quite a problem. Although most of the work in repairing breaks in the distribution system must still be done by hand, it has been found possible to increase the efficiency of the work by the use of certain mechanical equipment.

Services

The city of Winnipeg constructs and maintains the street portion of all services. Corporation cocks are tapped into the mains under pressure with five tapping machines, which can install services up to 8 in. in size under pressure. Stop- or curb cocks are installed 15 in. inside the street line to control the service. This practice is convenient in helping to determine which portion of a service is leaking. Both the corporation cocks and stopcocks are manufactured by the engineering department's own machine shop.

The original services installed in the city were of either galvanized- or wrought-iron pipe. Neither of these materials stood up in corrosive soil and all such services have since been replaced. Lead was used until it was found that the life of lead service pipe

in the Winnipeg area runs from about 30 to 40 years. The pipe then apparently becomes very brittle and granular, causing breaks to develop. Type K copper tubing has been employed in Winnipeg since 1924, with the exception of a few years during the war when its use was prohibited by the Metals Controller. This material has shown no signs of failure after 25 years, although its ultimate life cannot be predicted.

Originally services were installed at a depth of 6½ ft., but this was too shallow and resulted in services freezing during severe weather. All services on the street are now installed at a minimum depth of 8 ft. and the Water Works By-Law makes it mandatory for the private portion of the services to be installed at a minimum depth of 7½ ft. More trouble has been experienced with the private-property section of the service than with the city's portion. In the winter of 1935–36, an abnormally severe one, approximately 1,000 services were frozen, one-third of which were frozen on the street portion, while the remainder were frozen on private property. During a normal year there are about 50 frozen services on the street and an equal number on the property. To thaw out frozen services and mains, the department has a portable generator driven by a gas engine. This unit is mounted on a trailer with pneumatic tires and has a capacity of 600 amp. at 10–60 v. The department also has another thawing machine, consisting of a generator connected to a transformer which can be driven by an automobile engine. This unit is only used as standby or when additional equipment is required.

As explained previously, the curb cocks are located approximately 15 in. from the property line to enable the stopcock box to be placed on the concrete sidewalk in front of the premises. The city is divided into five districts and a meter man turnkey, equipped with a panel body truck, is assigned to each. He is responsible for the installation and operation of all stopcocks in his district. The city does not permit anyone other than authorized water works personnel to operate its valves and stopcocks.

In the winter, when the sidewalks are covered with snow and ice, it becomes difficult to locate these boxes. It is thus essential to have a good system of records. At Winnipeg, this information was formerly kept in four different records in bound sets of books. Because this was quite a cumbersome arrangement, it was decided, after a good deal of consideration, to try and coordinate the data more flexibly.

The changeover is just being completed. Each service is now listed on a separate card. The cards, arranged horizontally in trays, are filed by street and house number, and they contain: all information concerning the original installation of the service, including its service number, the size and kind of pipe, and its location, with both short and long measurements; the meter size, number and date of installation or removal, together with the reason for it; and turn-on and turn-off information. On the reverse side are shown any repairs that have been made and any required sketches. Each size of service has a distinctively colored card. Along the bottom edge of the card, space has been provided for the insertion of a colored flag indicating the meter size and the year in which it is to be removed for a routine test. If any information is required about the

service on any particular premises, the complete history can be obtained by going to the proper drawer and flipping to the card for that address. The size of the service and the meter, whether the service is on or off, and when the meter is to come out for test can be seen at a glance without even opening up the card.

The record of the more than 50,000 services is kept in cabinets in the dispatch room and is available at a moment's notice. This record will be put to even greater use when two-way radio is installed in the meter turnkey trucks sometime in 1949.

Valves

One of the most important types of equipment in any water distribution system is the control valve. Frequently the original design of a distribution system does not provide for enough valves, and Winnipeg was no exception. Before steps were taken to correct this condition, it was necessary in extreme situations to operate more than two dozen valves to effect a shutdown. This practice is the poorest type of economy.

As already mentioned, Winnipeg has a very large number of breaks to repair annually, which requires the shutting down of sections of mains, leaving customers without their normal supply of water. The department has adopted the policy of furnishing its customers with a temporary supply whenever possible. If the customers cannot be notified in advance to draw a supply, residential users are supplied by means of a water tank and commercial and industrial users by temporary hose service. Obviously the section which has to be shut down in emergencies can be materially reduced by increasing the number of valves in the system. As a result, it is now the practice to try and isolate service main sections no longer than 600 ft., three valves usually being installed at an intersection.

Because soil corrosion affects the valves and valve bolts, it was found more economical to go to the expense of using stainless steel bolts than to dig out the valves. Serious consideration is being given to having all valves installed in valve pits, a practice now followed for valves 10 in. and over. This plan permits regular maintenance, repacking and the like without the necessity for digging out the valves. Wooden valve boxes, originally placed on all the valves, rotted in a short space of time, making it impossible to operate them. As a result, the department now uses cast-iron valve boxes, of the telescopic type, made to its own standards.

In order to assist in regular maintenance and reduce the time necessary to shut off a section of main, the department operates a special trouble or "emergency" truck. The vehicle is in service 24 hours a day and is equipped with a Payne Dean Valve Operator Unit,* operated from the truck's power takeoff unit, which is used to open and close valves. Although this device can be employed on all sizes of valves, the department limits its use to valves 12 in. and larger. This piece of equipment is most useful, particularly on large geared valves. In the winter a Hauck Boiler, for thawing out valve boxes and hydrants, is mounted on the emergency truck. It also has the miscellaneous small tools, valve keys and lanterns necessary to deal with various difficulties, as well as a two-way radio.

* Made by Payne Dean & Co., Madison, Conn.

A very complete record of all valves operated is kept by means of a system of turn-off and turn-on cards. It is the regular practice to have these valves checked by a second emergency crew as soon as possible after action has been taken. This arrangement was adopted to make sure that valves which had been closed to shut off a main were

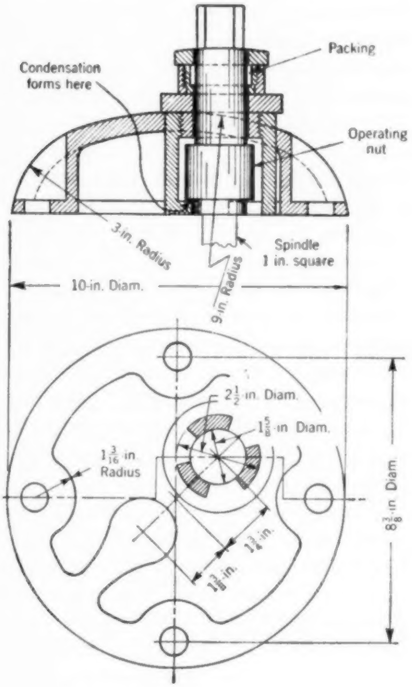

Fig. 1. Modified Hydrant Top

not left in that position when the main was again put into service.

Hydrants

As the hydrants were originally purchased on the open market with no attempt made to standardize them, there were more than a dozen different makes to be found in the system. The disadvantages of this practice were soon recognized, however, and a standard hydrant of the Corey type, manufactured by a local firm, was adopted. Later the city improved this hydrant by making certain modifications. Local foundries using the city's patterns now make the cast-iron and brass castings, which, along with other parts, are machined and assembled in the engineering department's own machine shops. Winnipeg considers the practice of fabricating its own hydrants, stopcocks, curb cocks and meter repair parts good business, and it certainly paid off during the war, when materials were in such short supply.

Hydrants are located at street intersections whenever possible and not more than 400 ft. apart. They usually sit about $8\frac{1}{2}$ ft. from the street line, which is far enough back of the curb to reduce the danger of being struck by vehicles and permits the installation of a shutoff valve, while still allowing enough room for small tractors with plows to clear the walks of snow.

The city tries to see that the hydrants are in operating condition at all times. In 1947, 30 hydrants were dug out for repairs, 709 light and heavy repairs were made, 83,687 inspections were made and 124 hydrants were painted at a cost of $22,330.

Most hydrant maintenance problems are due to freezing, usually resulting from improper use of the hydrant during cold weather, from the failure of the hydrants to drain, from slow leaks around the valve or from moisture around the operating nut.

As far as possible an attempt is made to prevent these troubles by good design. Whenever feasible, hydrants are drained to the sewer. In some areas, this practice is not permitted because of

the possibility of contamination, but Winnipeg's clay subsoil is almost impervious, and the use of drainage pits is not very satisfactory.

One of the modifications made was the gouging of the bonnet (*see* Fig. 1), thus reducing the contact surface between it and the spindle with a resultant decrease in the likelihood of freezing. The shaded area in the lower portion of Fig. 1 shows where part of the operating nut bearing has been gouged out.

A regular system of inspection has been set up, with every hydrant numbered and listed on a separate inspection sheet, which has ruled columns giving the date of inspection and the various reasons for which a hydrant may be unserviceable. An inspector is assigned to each of seven districts and is given a loose-leaf binder containing the inspection sheets of the hydrants in his district. Instructions and rules for inspection are rigidly adhered to. If an inspector finds a hydrant unserviceable, he notes it on the sheet, places an "out of service" cap over the operating nut and notifies the operating office as soon as possible. This information is passed along to the fire-police signal station so that the fire department always knows which hydrants are out of service.

From late October until the middle of May the hydrants in the commercial area are inspected at least twice a week, and at least once a week in the rest of the city. Inspections are less frequent during the summer.

One truck is used specifically for servicing hydrants and valves. A special heated body is put on this truck in the winter. In it is installed a Hauck Boiler, which provides steam to thaw out frozen hydrants and valves. The truck is also equipped with pumps to pump out hydrants that do not drain well after use. During the most severe part of the winter it is necessary to operate this truck sixteen hours a day.

Equipment

The department firmly believes in economizing by using mechanical equipment whenever possible. It is, of course, obvious that in the type of work being performed by the water department it is essential that this equipment be reliable and properly maintained. The mobile equipment of the department consists of eighteen trucks; six compressors, one of which is a self-propelled tractor-compressor; four tool trailers; a mobile crane; a trailer-mounted water tank; a mobile thawing machine; two trenching machines; a truck-mounted Buda-Hubron * earth drill; and over a dozen wheeled workmen's shacks, as well as numerous small miscellaneous equipment, such as pumps, lighting plants, tapping and pipe-pushing machines and pneumatic tools.

The department's mechanical equipment has more than doubled since 1939, but no proper storage facilities were provided, a situation which it was impossible to correct during the war. The vehicles had to be stored at several points in the city, some in dilapidated wooden buildings located in the Central Yards, others in an old gas producer building at the high-pressure plant. The spring of 1948 saw the completion of a new garage building located at the Central Yards. The building is 65 by 125 ft., part of it being two stories in height. It provides storage facilities for all mobile equipment for the water works and sewerage branch of the de-

* Made by Buda Co., Harvey, Ill.

partment, as well as space for greasing and washing. All repair work is done by the equipment section of the department in its repair shop immediately adjacent to the garage. There are also repair shop facilities for the hydrant and valve section. In the second-story portion of the building are located the most modern type of lunchrooms, washrooms, showers and locker rooms. Members of the branch can eat their lunch under pleasant, sanitary conditions and clean up and change clothes when they go to and from their work.

Important Elements

It may be useful to outline briefly the several important points which guide the department in carrying on maintenance and operational work.

1. *Design.* The first, and possibly the most important, step in reducing maintenance and repair work is good design. Ample thought, based on experience in the field, should govern the planning of all replacements and new work. Careful attention should be paid to making up specifications covering materials and their installation. A good plan is to make use of the excellent work done by Association committees on various specifications.

The question of standardization is most important. In municipally owned utilities it is usually difficult to specify or purchase specific manufacturers' products. Nevertheless, the advantages to be obtained, such as the reduction in the inventory of spare parts and the speeding up of repair work, warrant every attempt being made to follow this policy. In large cities, where the amount of material used justifies such a procedure, it might be found advisable to have a city standard. At Winnipeg, this has been done for hydrants, and experience has proved it worth while. In small communities such a system is not practical, and the only alternative is for the water works superintendent to try and persuade the governing authorities to limit his equipment to one or two makes.

2. *Inspection.* The second factor is proper inspection of the actual construction work. It is very important to have fully qualified inspectors in charge of the construction work as it proceeds in order to see that the plans and specifications are rigidly adhered to. The expense involved will pay for itself many times over. Although all the renewals and replacements are made by the water department, nearly all of the new construction work is done by the construction division of the engineering department. Nevertheless, it has been found advisable to have water works personnel act as inspectors on these jobs.

3. *Records.* The importance of setting up and maintaining an adequate system of records cannot be overemphasized. Such a system cuts down the time and reduces the cost of repairs and maintenance. It also reduces the possibility of claims. In main breaks, the city assumes no responsibility other than for negligence. A proper system of records goes a long way toward enabling the department to carry out its work in such a fashion that it can establish its efficiency in cases of claims in court. A proper system of records also prevents damage to other utilities, which is particularly important in cold climates where excavations are carried out in frost for seven months of the year.

4. *Planned maintenance.* The saying "A stitch in time saves nine" is never more applicable than to water works

maintenance. The author is definitely of the opinion that a system of planned maintenance results in better service to the community and in the long run more than justifies itself from a dollars-and-cents point of view.

5. *Labor and equipment.* Since the outbreak of the war there has been a shortage of labor, particularly in jobs calling for hard manual work under dirty, wet conditions, and no one can blame the men too much for disliking this work. In addition, the cost of labor has more than doubled in the last ten years. The only way to get the necessary amount of work done at a minimum expense is to use mechanical equipment whenever possible and to see that it is properly maintained.

Although there is no closed shop at Winnipeg, the men can belong to one of three unions, which are recognized by the city council. An agreement arrived at by collective bargaining sets out the working conditions, including overtime pay, sick leave and holidays. This agreement also establishes a procedure for dealing with grievances. On the whole, labor relations in Winnipeg have been conducted satisfactorily, resulting in excellent cooperation between labor and management.

As the work in the water department calls for a number of specialized skills, the open labor market cannot be relied on to supply this need. Recognizing this fact, the department set up an apprenticeship system in 1934. Young men under the age of eighteen, on completion of their high school training, are taken into the department to serve a four-year apprenticeship. During this time they are trained in various sections of the department so that at the end of their course they are generally familiar with the different jobs, and management has an excellent idea of the capabilities of the individual apprentices. During the war it was impossible to obtain first-rate apprentices, but this practice has now been resumed and improved by adding a series of tests, used first of all as a basis for acceptance, and, second, to keep a check on the progress made.

In the last analysis, the quality and quantity of work done by any organization is directly dependent on its labor forces. As already mentioned, there has been quite a change in labor conditions in the last ten years and management has to keep up with the times. In order to make the best use of mechanical equipment it is necessary to have intelligent, well trained personnel. Every effort should be made to see that the turnover of personnel is kept to a minimum. This can best be done by recognizing labor's position in modern industry and giving the men a sense of contentment and security. They in turn will usually develop a pride in their work and feel that they are part of an important organization.

Water Use by Air-Conditioning Equipment

By Lewis L. Barnes

A paper presented on Dec. 7, 1948, at the Southeastern Section Meeting, Augusta, Ga., by Lewis L. Barnes, Chief Engr., Carrier Atlanta Corp., Atlanta, Ga.

BECAUSE of the growth of the air-conditioning industry, water use by air-conditioning equipment has become increasingly significant. Some municipalities have been forced to invoke restrictive measures; others may soon find they must take similar steps; but still others may never find it necessary to follow this course. It is therefore appropriate to take a clear view of the subject at this time in order to evaluate its importance and study corrective measures if applicable.

The term "subject" is used rather than "problem" because the consumption of water by air-conditioning equipment is not necessarily a problem unless local factors make it one. A study of this water usage should be entirely local in scope, and since so many local conditions complicate or simplify the problem, this discussion will, of necessity, be held to generalities, with no attempt being made to recommend procedure for purely local situations.

Condensers

All air-conditioning systems employing mechanical refrigeration require some means of cooling the compressed refrigerant gas in order to condense it back to the liquid state. One of the most popular methods is the use of the air-cooled condenser, but unfortunately its overall efficiency is so low that it is not generally practical except in very small installations.

On larger installations, it is quite common to use a water-cooled condenser, employing the public water supply as the cooling medium. This device usually consists of a shell-and-coil type of heat exchanger, with water passing through the coil and cooling the refrigerant gas which comes in contact with the outside of the coil. In this process, the temperature of the water is raised to a point at which it is no longer useful as a cooling agent and must be rejected in favor of water at a lower temperature. There is obviously a continuous flow of water through the condenser while the equipment is in operation, amounting to approximately 1.5–2.5 gpm. per compressor horsepower at full load. It is apparent that this method can result in the wasting of large quantities of water which has undergone no other change than that of a 15–20°F. rise in temperature. For example, a 10-hp. air-conditioning compressor, using city water at the rate of 2.0 gpm. per horsepower, consumes 20 gpm., 1,200 gph. and 9,600 gal. or 1,270 cu.ft. per eight-hour day. These figures may not be impressive to those accustomed to thinking in terms of millions of gal-

lons per day, but with a multiplicity of installations, the water consumed can become a significant load on the city water mains. Whether this load is desirable or undesirable depends on local conditions, but it must be borne in mind that it generally occurs during the summer months and may coincide with other peaks.

The air-conditioning installation just described is relatively low in initial cost to the owner, but, depending on local water rates, could be quite expensive to operate because of the high water consumption. Installations of this type are usually equipped with an automatic water-regulating valve to insure against using more water than is required under less than the maximum load. It has been the author's experience that these valves are adequate for adjusting water flow to meet load conditions but should not be relied on to effect complete closure during shutdown periods. It must not be overlooked that, in certain localities, the disposal of waste condenser water constitutes just as great a problem as does the supply of this water in other localities.

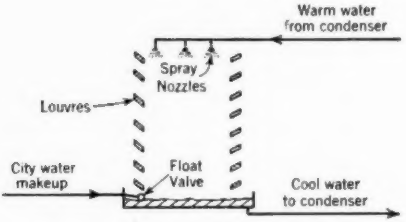

FIG. 1. Atmospheric Cooling Tower

The wasting of condenser water could sometimes be objectionable on account of inadequate supply or disposal facilities, high costs, high initial temperatures, poor chemical characteristics and other factors. It is well to consider, therefore, some of the most common means of combating this problem.

Conservation Devices

The water-cooled condenser described previously can be used in conjunction with a cooling tower or spray pond, which, if properly designed and installed, can recapture approximately 95 per cent of the water otherwise wasted. This saving is accomplished by recooling the warm water discharged from the condenser and returning it to the condenser by means of a circulating pump.

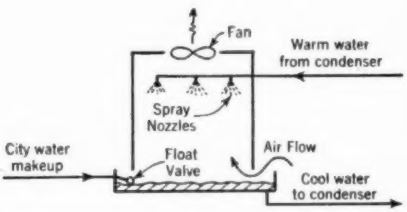

FIG. 2. Induced-Draft Cooling Tower

The atmospheric cooling tower (Fig. 1) depends entirely on natural wind and air currents to cool the condenser water effectively. It is suitable for location only in places where free and unobstructed air flow is available. Many installations of this type have failed to produce the desired results because the tower was located in a light court or on the lee side of some obstruction.

The induced-draft cooling tower (Fig. 2) is equipped with a motor-driven fan to create its own draft. This type can be located in many positions which would be unsuitable for the atmospheric tower, but obviously its initial cost is greater.

The spray pond (Fig. 3), commonly used as a water conservation device, has certain advantages as well as disadvantages when compared with cooling towers. Job conditions should govern the choice.

The cooling towers and spray pond will perform the desired task of water cooling with varying degrees of efficiency, depending on local conditions. They are all readily suitable to existing water-cooled installations, with the adaptation usually consisting of simple piping changes and the addition of a circulating pump. It should be remembered that the addition of the water-circulating pump will increase the use of power, a fact which must be considered when evaluating operating costs.

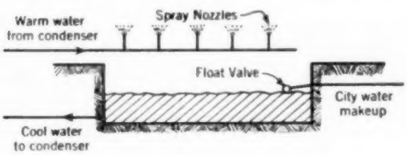

Fig. 3. Spray Pond

The evaporative condenser (Fig. 4) is one of the most efficient means of condensing with minimum water requirements. In this device, the refrigerant gas is cooled directly by a combination of air and spray water passing over the condensing coil. Only one heat transfer is necessary (gas to water and air), as contrasted with the cooling tower or spray pond, which require two heat transfers (gas to water, and water to air). The evaporative condenser is very compact and frequently can be placed in locations which are not practical for cooling-tower installations. On new installations, the evaporative condenser compares favorably in first cost with cooling towers and spray ponds. If water-conserving equipment is to be applied to existing water-cooled equipment, the cooling tower is usually cheaper than the evaporative condenser, in that the tower installation continues to utilize the existing water-cooled condenser.

Conclusion

The foregoing is intended to familiarize the reader with the basic equipment generally used in air conditioning. It has been shown that there are means which can be employed to reduce materially the amount of city water consumed by an air-conditioning system. The owner and the designer of the system must decide which type of equipment to use, basing their selection on several considerations, including the economics of first cost versus operating cost, the availability and cost of water and power, space limitations, accessibility, maintenance cost and architectural appearance. These items vary for each job and for each locality.

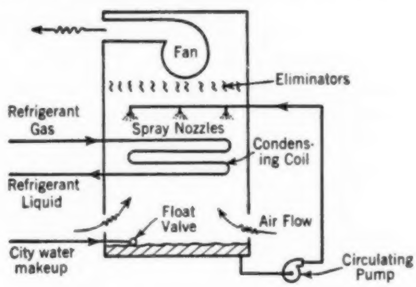

Fig. 4. Evaporative Condenser

From the viewpoint of those in the business of supplying water, the subject can be summarized by stating that:

1. The water load imposed by air-conditioning equipment can be attrac-

tive to those systems which have ample water for sale during the summer months.

2. This load can be unattractive to those systems which have a deficiency of water in the summer if the return from water sales will not justify additional investment in plant or distribution facilities.

Water systems which cannot stand this load imposition must work out the problem through local channels. Some cities have been forced to invoke restrictive ordinances to prohibit the indiscriminate wasting of water. All ordinances of this nature should be flexible enough to prevent undue hardship when the installation of water-conserving equipment is impractical, as it might be for the tenants of office buildings, for example. Some thought should be given to the possibility of instituting demand charges to compensate for the standby facilities when no water is being used. It must be realized that restrictions placed on only one class of user are discriminatory and can become very unpopular. In general, however, the users and installers of air-conditioning equipment will be sympathetic and cooperative in planning the solution to these problems.

Need for Proper Valve Records

An extract from the March 1949 issue of "Michigan Water Works News" (**9**:*2:9*), *issued by the Div. of Eng., Mich. Dept. of Health.*

The need for properly located valves and routine valve inspections at frequent intervals was very vividly brought to our attention recently, when in the office of a city water superintendent. A hydrant barrel had been broken off a few days previously and plans had been laid to repair it. Unfortunately, there was no valve in the hydrant leg; therefore, it necessitated taking out of service mains for one block on each side of the hydrant. Customers along these two blocks had been informed that the water would be off a couple of hours. One of the three valves which was to be closed did not hold; therefore, it was necessary to go back another block. Soon calls were being received from consumers several blocks outside the supposedly affected area that they had no water. It was entirely unexplainable; however, calls continued to increase. Finally, upon investigation, it was found that a valve was closed on the line which was supposed to have rerouted the water to the area from which the calls were being received. It was recalled that a couple of years ago the stem on this valve had either been bent or broken with the valve in the closed position and had never been repaired. With the pressure back on the system, calls were received about red water, which was to be expected after the way the water had been changing direction for an hour or so. This very same embarrassing situation could happen at many of our towns throughout the state. The important thing is that we all profit by this experience and not be too sparing on valves when new main extensions are made and particularly that we install valves on all hydrant legs. The program must not stop here, though, since a valve is no good whatsoever if it has not been operated in years and will not seal properly or cannot be closed for some other reason. It is imperative that a routine inspection at frequent intervals be made of all valves. It is equally important that the exact location of each valve be known and adequately referenced to permanent objects, and that information be available as to whether it is a right- or left-hand valve, as well as the number of turns required to open or close it.

A New Method of Odor Control

By D. B. Williams

A contribution to the Journal by D. B. Williams, In Charge of Purif., Brantford Water Works, Brantford, Ont. This paper is based upon the author's experiences in the treatment of the Grand River water at Brantford, Ont. This stream not only receives municipal wastes but also is adversely affected by wastes from textile mills, synthetic plastics and other industries. Irregularities in the discharge from an impounding reservoir on the watershed complicate the control of water treatment.

FROM observations at Brantford, Ont., and also from papers dealing with free residual chlorination in other areas, it is increasingly apparent that formation can become nitrogen trichloride (NCl_3) a serious hindrance to free residual chlorination. The academic literature disposes of the subject of NCl_3 formation in water by the statement that it will not occur unless the pH of the water is 4.4 or less. In the light of present knowledge, this assertion is true of combined residual chlorination but is not true for alkaline waters high in nitrogenous matter where free chlorine residuals are maintained.

As the literature on NCl_3 formation and removal in water works practice is rather meager, the author offers this paper with the hope that the information contained in it will be of value to others who have experienced difficulties with NCl_3.

Sudden Appearance of NCl_3

Free residual chlorination plus dechlorination by sulfur dioxide to a 1-ppm. free chlorine residual had been in practice at the Brantford plant for several months without NCl_3 forming. For a two-week period brief flashes of a "chlorinous odor" were noticeable at the plant, leading the author to suspect NCl_3 formation. However, in view of statements in the literature, together with the fact that the raw water had a pH of 8.0–8.5, it was felt that NCl_3 could not possibly form under the prevailing conditions. Suddenly, in March 1948, the entire plant was filled with a very pungent "geranium type" odor. Furthermore, this odor was objectionably noticeable whenever a tap was turned on in any part of the distribution system. Though not absolutely sure, the author strongly suspected NCl_3. This suspicion was confirmed by Robert Van Burek, Dist. Mgr., Wallace & Tiernan Co., who, being engaged in the production of NCl_3 in other industries, readily identified it.

Should the water works operator be unfamiliar with NCl_3 and yet feel that it is forming in his plant, the following simple identification procedure will be of value:

1. To flask *A* of 500-ml. capacity add 250 ml. of water suspected to contain NCl_3.

2. To flask *B*, also of 500-ml. capacity, add 250 ml. of distilled water plus a few crystals of ammonium chloride (NH_4Cl). To this dilute NH_4Cl solution, add just sufficient chlorine water (from a chlorinator water tray, if necessary) so that a small portion of the sample separately treated with ortho-tolidine indicates the presence of free Cl_2 (ortho-tolidine flash procedure).

NCl_3 will always form under the conditions in flask *B*. Therefore, by shaking both flasks vigorously and then sniffing the resultant odors, positive identification of the presence or absence of NCl_3 in flask *A* is obtained. If the concentration of NH_4Cl and free Cl_2 is too high, the resulting concentration of NCl_3 will be far higher than is met with in the most aggravated instance in general practice and hence ready recognition may not follow. The worker should use NH_4Cl and Cl_2 sparingly in flask *B*. It should be realized that the odor of NCl_3 seems to vary rather widely in nature, depending on its concentration and temperature. Thus, although the author generally describes the odor as being of a geranium type, many others classify it differently. Of importance is the fact that some practice with this procedure leads to positive identification of NCl_3. Depending on the concentration of NH_4Cl and Cl_2 in flask *B*, NCl_3 may take less or more than ten minutes to form. Both flasks should be stoppered throughout the experiment except during brief odor observation. At the termination of the observations (half an hour) flask *B* should be thoroughly washed out with tap water to obviate the possibility of an explosion due to NCl_3.

Following positive NCl_3 identification at Brantford, laboratory work showed that the addition of ammonia suppressed the odor of NCl_3. Unfortunately, in plant practice this required a concentration of ammonia high enough to make the finished water pink to phenolphthalein. Although the NCl_3 as such was removed, this treatment merely exchanged a volatile and quickly dispersed odor for a decidedly objectionable taste.

Partial dechlorination with sulfur dioxide prior to the addition of ammonia was no better. As both procedures were unwieldy and impractical, they were abandoned. The temporary answer was dechlorination to a very low residual (0.05 ppm.), a procedure employed from March to November 1948. Under such operation, the magnitude of the residual permissible to prevent NCl_3 from being objectionable will vary according to the temperature of the water and the concentration of NCl_3 present. To meet differing conditions, this low residual was found necessary at Brantford.

Laboratory Study

With dechlorination to a low residual a good temporary expedient, a laboratory study of NCl_3 formation and its subsequent removal was then made.

Since NCl_3 is the result of a reaction between free Cl_2 and nitrogenous compounds, an investigation of the forms of nitrogen in the raw water seemed of first importance. This resulted in the finding of free ammonia, protein matter (loosely termed albuminoid ammonia), nitrites and nitrates.

The chlorination of solutions of nitrite and nitrate salts ($NaNO_2$ and KNO_3) to a free chlorine residual showed that nitrites and nitrates do not react with free Cl_2 to produce NCl_3.

The reaction between "free" and "albuminoid" NH_3 and free Cl_2 was studied by separating these two forms of nitrogen by means of an ammonia distillation apparatus. The free NH_3 would be in the distillate and the albuminoid NH_3 would remain in the residue. After diluting these two fractions, separately, back to the original sample volume and then chlorinating both to obtain a free chlorine residual, it was found that both formed NCl_3.

A. E. Griffin, Tech. Director, Wallace & Tiernan Co., rightly criticized the chlorination of the free NH_3 fraction since it was essentially in distilled water (with a pH less than 7), a condition always tending to result in NCl_3 formation. Refinement of this experiment by raising the pH of this distillate to definitely alkaline conditions—using lime water or sodium carbonate—and then chlorinating to a free chlorine residual still resulted in NCl_3 formation.

There was no criticism of the chlorination of the "albuminoid NH_3" residue since alkaline conditions were at all times present because of the natural alkaline salts remaining in the residue.

The possibility of concentrations of low pH at the point of chlorine application in the plant was ruled out by chlorinating samples above the breakpoint in the laboratory, employing rapid stirring and dilute chlorine water. This procedure was repeated using highly alkaline hypochlorite solution. In both experiments, NCl_3 formed above the breakpoint. On account of the ready volatility of NCl_3, this work was performed in stoppered flasks.

It is urged that, when running a series of samples for chlorine demand investigations, the work be performed in glass-stoppered bottles. The "open-beaker" technique permits NCl_3 to disperse at low concentrations as rapidly as it is formed, possibly leading the worker astray later. In closed bottles the NCl_3 remains very apparent, and the worker can expect it to form under similar conditions in his plant.

In the experiment with free NH_3, it was noticed that the addition of Cl_2 above the breakpoint resulted in an early formation of NCl_3, generally after not less than ten and not more than twenty minutes. On the other hand, with albuminoid NH_3, the NCl_3 usually requires at least two hours to form, and often longer. It should be noted that the higher the free chlorine residual is above the breakpoint (or the higher the free chlorine residual), the quicker will be the formation of NCl_3 from albuminoid NH_3.

Adding chlorine water gradually was tried on raw water, on alkaline-free NH_3 distillates and on albuminoid NH_3 residues. In all these tests, the NCl_3 formed as soon as a free Cl_2 residual was present.

The theory that chlorination just to breakpoint level will produce a water virtually free of combined available chlorine, free available chlorine and NCl_3 has been substantiated in laboratory work. Because of the great variation in the free and albuminoid NH_3 content of Brantford's two sources of raw water, coupled with the highly variable pumpage, true breakpoint operation is impractical in the plant, so that this theoretically desirable method of preventing NCl_3 formation could not be used. Morever, best results are obtained at Brantford when operating with a 2-ppm. free chlorine residual. Therefore, it was soon apparent that NCl_3 was a major problem to be faced if the procedure of free residual chlorination was to be continued.

Activated Carbon

Laboratory work shows that the use of activated carbon is an excellent method of removing NCl_3 if the plant design and general operating conditions are favorable. The author understands that activated carbon is used in a number of plants elsewhere for this purpose, giving the desired results.

D. C. Colebaugh, of the West Virginia Pulp and Paper Co., spent a week at the Brantford plant in July 1948 working with the author on the removal of NCl_3 by carbon. At that time laboratory and plant results showed that NCl_3 can be removed by the application of 5–15 ppm. carbon at a cost in Canadian funds of approximately \$30 to \$70 per 24 hours. Following Colebaugh's visit, the author continued to operate the plant in this carbon dosage range, meeting with two serious objections to the use of carbon for eliminating NCl_3.

The first difficulty is that, although the Brantford plant can operate above the 15-ppm. dosage successfully for a few days, continued operation at such a level results in carbon passing the filters, producing black water in the city. Finally, it was found that any dosage of carbon above 1 ppm. was objectionable on these grounds under conditions of continued application. This situation is not the fault of the carbon but is rather a matter of inadequate design for coagulation, resulting in an inability to hold carbon on the filters where it is at its best in NCl_3 removal.

Further work also showed that as the summer progressed the free NH_3 (which forms NCl_3 quickly with Cl_2) decreased, while the albuminoid NH_3 (forming NCl_3 slowly with Cl_2) increased. Consequently, very little NCl_3 was formed ahead of the filters, whereas the reaction between free Cl_2 and albuminoid NH_3 produced copious amounts of NCl_3 after filtration. It should be realized that carbon in the 5–15-ppm. dosage range successfully removed the NCl_3 but still permitted a high level of free chlorine to pass the filters. This high level of free Cl_2 plus unreacted albuminoid NH_3 produced post-filter NCl_3.

It became apparent from this work that to use carbon successfully, structural changes must be made to improve coagulation and to hold free chlorine in contact with the water longer prior to filtration. Carbon cannot presently be employed for NCl_3 removal.

Aeration

J. F. MacLaren, of Gore & Storrie, Toronto, who was interested in seeing aeration experimented with for other possible uses, suggested its trial in eliminating NCl_3. On a laboratory scale, NCl_3 removal by aeration is very promising and, in fact, is used with varying degrees of success at several plants.

A plant trial of aeration was made using 20 cfm. of air, the average pumpage at the time being 5 mgd. (Imp.). The air was diffused up through the water from sewage type diffuser plates. It was obvious that some NCl_3 was being removed by aeration but the total improvement was negligible. It has been estimated that approximately 1,000 cfm. will be required for complete success. To install sufficient aeration a capital outlay of approximately \$20,000 would be required. With other, more pressing capital outlays imminent and a serious provincial power shortage, the use of sufficient aeration for NCl_3 removal is temporarily not available to Brantford. Operating costs

alone—not including capital outlay, maintenance and depreciation—would be approximately $20 a day for 1,000-cfm. aeration.

Furthermore, although it is desired to send out a free chlorine residual stripped of NCl_3, it has been found that even with long retention at high free chlorine levels all the albuminoid NH_3 has not been completely reacted by the time it reaches the proposed aeration point. It is apparent that, while sufficient aeration would remove all NCl_3 formed up to that point, some albuminoid NH_3 remaining in the outgoing water could continue to react with the free Cl_2 residual, thus generating additional NCl_3 in the distribution system.

Recent laboratory work shows that the retention time with free chlorine needed to remove all of the protein matter in the water will be days instead of hours. This fact may always make it impossible to send out a free Cl_2 residual.

Basic Reactions Involving NCl_3

Griffin (1), in an important paper on chlorine and ammonia, discusses certain analytical considerations which disclose that the gas NCl_3 is reduced to a soluble form of ammonia by sulfur dioxide (SO_2). This phenomenon provides an explanation of several laboratory observations:

1. NCl_3 may be removed successfully by dechlorinating almost to a zero residual, because the NCl_3 is reduced to a tasteless, odorless form of ammonia. Unfortunately, this method does not permit sending out a chlorine residual and therefore is not a desirable procedure. Postchlorination following NCl_3 reduction by SO_2 only regenerates NCl_3.

2. The use of carbon or aeration can successfully eliminate NCl_3 formed after free residual chlorination and prior to dechlorination with SO_2. The reason is that NCl_3 is present as a gas and is readily removed by sufficient air or carbon.

3. Aeration and carbon are not able to remove soluble ammonia salts from water; hence, the use of air or carbon prior to free residual chlorination will not prevent subsequent NCl_3 formation. The same is true of air or carbon applied following complete dechlorination with SO_2; the ammonia is in a soluble form and postchlorination reforms NCl_3. To remove NCl_3 successfully, aeration and carbon must be applied following free residual chlorination and prior to partial dechlorination with SO_2 if it is desired to send out a free Cl_2 residual stripped of NCl_3.

4. The generation of NCl_3 by a reaction between nitrogenous compounds in water and free chlorine, and its subsequent reduction to a form of ammonia by SO_2, is a reversible reaction which may be made to proceed in either direction at will by alternate additions of free Cl_2 or SO_2.

In addition, certain other facts are worth recording:

1. NCl_3 is quite volatile and may readily escape into the atmosphere in plants where coagulation basins and reservoirs are open to the air. The retention time is all-important.

2. Sunlight destroys NCl_3 readily, although this fact is of no help at night and of only partial value on dull days. As the Brantford plant is completely "closed," the volatility of NCl_3 and its susceptibility to sunlight provide no advantage, although these characteristics

are of some apparent benefit at other plants.

3. On prolonged storage of water in which some albuminoid NH_3 remains, the free Cl_2 is used up. It has been found that, under these conditions, the disappearance of free Cl_2 is coincident with the disappearance of NCl_3. The author has proposed the possibility that during prolonged storage NCl_3 can react with some remaining nitrogenous matter, thereby being converted to something other than NCl_3. The speed of this reaction is naturally greater in warm summer water, but even at the higher temperatures, to remove NCl_3 by storage would require a phenomenally long retention time.

4. The reactions between free NH_3 and Cl_2 beyond the breakpoint to produce NCl_3 are for all practical purposes complete within one hour, whereas albuminoid NH_3 and free Cl_2 continue to react for hours (and even days, if sufficient free Cl_2 is present) to produce NCl_3.

5. Little or no NCl_3 is formed in the early stages of the Brantford plant when free NH_3 is below 0.05 ppm. as N, but recently copious NCl_3 formation has been noted in the later stages of the plant, with a relatively low albuminoid NH_3 of 0.11 ppm. as N in the virtual absence of free NH_3.

When free NH_3 is present to the extent of 0.10–0.25 ppm. as N, the formation of a heavy concentration of NCl_3 takes place in the early stages of the plant and is later supplemented by more NCl_3 from albuminoid NH_3.

In the complete absence of free NH_3 (a late-summer condition), the apparent concentration of NCl_3 in the later stages of the plant is dependent on the degree of free residual chlorination and the amount of albuminoid NH_3 present in the raw water. Since its first appearance in March 1948 the NCl_3 has always been present in objectionable concentrations at the later stages. No explanation of why NCl_3 was not apparent prior to March 1948 under free residual chlorination is offered, but its cause under present conditions is known.

Faced with all of the foregoing information, Brantford temporarily dealt with NCl_3 by dechlorination with SO_2 to a near-zero residual from March 1948 to mid-October 1948.

With the exception of dead ends, this procedure was generally very successful. However, in late October 1948 intense aftertastes appeared in the distribution system and caused complaints, even though the water leaving the plant was quite satisfactory. These tastes would be apparent for only brief periods in high-flow areas but persisted for two or three days in areas of low flow. Careful checking showed that, in trying to keep NCl_3 from being noticeable by dechlorinating to a low residual, an excess of SO_2 was being sent out for brief periods (in the absence of automatic equipment), thus causing or permitting the formation of aftertastes of a "medicinal" type.

It was obvious that continuance of this practice would raise serious objections on account of the tastes whereas reduction of the SO_2 dosage to permit a free Cl_2 residual would eliminate the tastes but restore the NCl_3 odors. It should be mentioned that the tastes in the system were spotty and of brief duration, while the NCl_3 odor would be general and would continue.

Since any kind of chlorine residual would prevent the tastes, the problem was how to maintain such a residual free of NCl_3. On November 3, 1948,

the author suggested a procedure by means of which the plant could continue to use free residual chlorination, remove NCl_3 by conversion and send out a chloramine residual to prevent aftertastes. The laboratory work and plant operation involved in what the author believes to be a new method of dealing with NCl_3 are described below.

NCl_3 Removal by Conversion

River samples were chlorinated well beyond the breakpoint, copious NCl_3 formation resulting. Complete dechlorination to zero Cl_2 residual followed, reducing all NCl_3 to a soluble form of ammonia. The addition of Cl_2 at this point would have naturally regenerated the NCl_3. Instead of adding Cl_2, the ammonia from the NCl_3 reduction was fortified by the addition of more ammonia. Next free chlorine was added in such concentration that it would be substantially below the "breakpoint level" induced by the sum of these ammonias. This resulted in a combined chlorine residual—a chloramine—entirely free of NCl_3. By insuring that the postchlorination dosages were maintained below the breakpoint levels set up by the total ammonias (a normal chloramination procedure) no NCl_3 was formed and yet a simple means was provided of sending out at least a chloramine residual, to prevent aftertastes.

Repeated laboratory trials always gave the same successful results, warranting a plant trial.

Plant-scale operation of this process started November 20, 1948. Free residual chlorination ahead of the mixing chamber was continued permitting water containing a high level of 100 per cent free chlorine plus NCl_3 to pass through the coagulation basins, filters, clear well and storage reservoir. The SO_2 is discharged to the water at the exit from the reservoir. At the end of the pipe from the reservoir to the pumproom, a pump withdraws samples to insure zero Cl_2 and zero NCl_3, the SO_2 feeding equipment being adjusted accordingly. The water then enters a small concrete chamber into which ammonia gas is applied. Leaving this chamber the water flows into the pump well where sufficient Cl_2 is added to produce a true chloramine residual free of NCl_3. Summarizing, the process consists of four steps:

1. Free residual chlorination (superchlorination for a considerable period to oxidize phenols and other taste- and odor-producing substances), carrying with it the burden of NCl_3.
2. Complete dechlorination by SO_2 to zero chlorine residual reducing all NCl_3 to ammonia.
3. The fortification of this ammonia by additional ammonia.
4. A postchlorination dose added to these ammonias to form a highly stable residual completely free of NCl_3.

It is apparent that in all water works where free residual chlorination is found to be necessary but where NCl_3 is a serious cause of complaint, the total removal of NCl_3 may be accomplished by the simple application of dechlorination with SO_2 followed by the equally simple application of the well known ammonia-chlorine process. The author realizes that the addition of ammonia following free residual chlorination has often been made for the purpose of sending out a chloramine residual. However, the novelty of the present method lies in the complete dechlorination to remove NCl_3 and the subsequent addition of

ammonia and chlorine to provide a residual in a manner preventing NCl_3 from leaving the plant.

Plants experiencing NCl_3 formation in acid waters are encouraged to try the above procedure rather than give up free residual chlorination for some other method. In this regard, it has been shown that free Cl_2 residuals increase in activity as the pH decreases; hence free residual chlorination at a low pH should be even more efficacious in acid waters than in the alkaline supply at Brantford. Should the pH be so low (4.4 or less) that the addition of a chloramine residual, following complete dechlorination with SO_2, permits NCl_3 formation, the raising of the pH between SO_2 applications and the addition of NH_3 and Cl_2 afterward would be called for. Such an acid water would in any event require alkaline additions for corrosion control.

Evaluation of Process

From the beginning, purely as a chemical process, the author's NCl_3 removal method worked successfully, sending out a chloramine residual free of NCl_3 regardless of high or low concentrations of NCl_3 in the plant water. It is suggested that this procedure may take its place alongside carbon and aeration for NCl_3 removal; moreover it appears to be more flexible and more economical than these other methods.

The mechanical difficulties which have occurred were not insurmountable and have been or are being corrected.

Erratic prechlorination to too high a level for brief periods makes necessary frequent adjustment of the SO_2 feeding equipment. The installation of a chlorine residual recorder and an alarm system is planned to smooth out this condition.

Too low a dosage of SO_2 will permit some NCl_3 to pass the dechlorination point and thereafter nothing can stop it. With smoother chlorination plus automatic SO_2 feed control based on pumpage, this condition will be removed.

Too high a dosage of SO_2 can reduce the following chloramine residual to zero, permitting undesired excess SO_2 to go out. This will be corrected as above.

Generally these conditions happen very infrequently under manual operation, a fact which is a tribute to the careful attention given by the operators to this process. Control of the entire process is relatively simple. Free residual chlorination is adjusted by the flash (five-minute) ortho-tolidine technique. Dechlorination control is also carried out by the use of ortho-tolidine. As a new operator comes on shift, he gradually decreases the SO_2 dosage until a faint residual is perceptible and then raises the dosage 5 lb. Throughout the shift the operator then maintains sufficient SO_2 feed to give a precise zero residual following the point of SO_2 application.

Even with variable pumpage, the ammonia-chlorine additions are not troublesome. A 1:2 ratio of NH_3 to Cl_2 was established after trying a 1:4 and 1:3 ratio. The ammonia feeder usually runs in the 12–15 lb. per day range, with the chlorinating apparatus delivering 24–30 lb. The dosage could actually be left constant, giving a final residual of 0.2 to 0.4 ppm. chloramine. The ammonia-chlorine addition is so untroublesome that a high outgoing residual immediately warns the operator of free Cl_2 and NCl_3 passing the dechlorinating point. The reverse is true of excess SO_2; hence, the ammonia-

chlorine treatment requires very little adjustment, whereas close observation of dechlorination is all-important. On several occasions when the NCl_3 was very pronounced in the reservoir, this process has been purposely thrown out of balance for fifteen-minute trials to test its efficacy. When the SO_2 was cut off, while continuing the ammonia-chlorine application, the NCl_3 passed right through. With the SO_2 normal (reducing NCl_3), the NH_3 cut off and postchlorination continued, NCl_3 was regenerated by the chlorine. Restoring the SO_2 and ammonia-chlorine applications to normal, no NCl_3 resulted and a chloramine residual was present.

This process immediately eliminated the aftertaste flareups in the high-flow areas and is pushing out into the areas of low flow and dead ends, bettering conditions there.

Since the process has been in use two floods have occurred, as a result of which the free NH_3 increased in the raw water, causing very high concentrations of NCl_3—far higher than at any previous time. It is worth noting that this procedure was continued quite successfully. Not only does it operate successfully under varying concentrations of NCl_3, but it works just as well when the NCl_3 is entirely due to albuminoid ammonia-chlorine reactions, as in a mixture of free NH_3 and albuminoid NH_3 with Cl_2.

Assuming that prechlorination and dechlorination equipment is already on hand, this procedure requires only the installation of an ammonia feeder and postchlorinating apparatus. Originally the ammonia and postchlorination costs were on the order of $3.50 per 24 hours. Now, with the installation of a Wallace & Tiernan automatic sulphonator, this cost has been reduced to $1.50 a day. Even with the use of either carbon or air for NCl_3 removal, SO_2 would still be needed for partial dechlorination. Therefore, only part of the SO_2 can be rightly charged to this process. On this basis, the SO_2 costs for the process are approximately $3.00 a day. The total cost for NCl_3 removal may be stated as approximately $4.50 per day. If the cost of all of the SO_2 used were charged to the process, the total cost would only be $10.50 a day.

High flexibility, low cost of operation, low capital outlay, simplicity in operation and small space required for equipment are all desirable features of this process.

Acknowledgment

The kind cooperation of D. C. Colebaugh, West Virginia Pulp and Paper Co., in the carbon work is sincerely appreciated. J. F. MacLaren, Gore & Storrie, Toronto, and Robert Van Burek, Wallace and Tiernan, Ltd., Toronto, assumed the responsibility for the engineering details of the NCl_3 removal process, thereby contributing greatly to its success.

Reference

1. Griffin, A. E. Chlorine for Ammonia Removal. Proc. 5th Ann. Water Conf., Engrs. Soc. West. Pa. (1944).

Amendments to A.W.W.A. By-Laws

The following amendments to Article II (Admission and Expulsion) of the Association's By-Laws were approved by the Board of Directors, by letter ballot, as of February 21, 1949:

The second paragraph of Section 2.1 is changed to read:

> Applications for Associate Membership shall provide adequate information concerning the ownership, corporate structure and financial standing of the applicant; and the experience of the customers in the water works industry with the applicant firm. When such information has been received by the Secretary, he shall refer it to the Executive Committee of the Board for consideration and approval or rejection. The Executive Committee shall establish such detailed criteria for Associate Membership as it deems necessary to the discharge of this duty. These criteria, when approved by the Board, may be, in the case of failure of a member to continue satisfactory business practices, the basis for expulsion from membership under the terms of Section 6 hereinafter.

This means that the A.W.W.A. office will be required to obtain from all applicants for Associate Membership information concerning the business activities of the applicant as indicated in the first sentence of the above By-Laws subsection. It further means that when the information has been received, it will have to be referred to the Executive Committee; and, not until the Executive Committee has approved the application, will it be possible for the Secretary to include such an application in the list of names to be voted upon by the officers and directors. This procedure will delay the processing of applications for Associate membership.

The closing paragraph of Section 2.1 is transferred to Section 2.2, which will now read:

> 2.2. Applications shall be forwarded by the Secretary to the Board for approval when the above conditions have been met. An affirmative vote of a majority of the Board shall elect and the applicant shall become a member when his annual dues shall have been paid.

Section 3 is changed to read:

> No member whose dues are in arrears for *three* months shall receive the publications of the Association until such arrears are paid. Members in arrears for one year shall be automatically dropped by the Secretary from the list of members.

This means that members of the Association whose dues remain unpaid at the end of March will not receive copies of the JOURNAL or other official publications of the Association until their dues are paid. Heretofore the credit period was extended to the end of April.

Tentative Manual

of

CATION EXCHANGER TEST PROCEDURES

(Ion-Exchange Materials—Cation Exchangers Operating on the Sodium Cycle—Commonly Termed "Zeolites")

The American Water Works Association issues this text as a *Tentative Manual.* The Manual was prepared by a committee appointed by the Water Purification Division, which committee operated under the jurisdiction of the Committee on Water Works Practice. This is a Tentative Manual, *not* a set of specifications. It may be adopted as a *Standard Manual* after due time has elapsed. It is intended to be a general guide to persons having occasion to purchase cation exchangers to be used in water purification, but it is not intended to be a substitute for, nor to be superior to, competent engineering judgment based upon a complete understanding of special conditions.

American Water Works Association

Approved as Tentative by the Board of Directors of the A.W.W.A. on December 31, 1948

First Printing, May 1949

AMERICAN WATER WORKS ASSOCIATION
Incorporated
500 Fifth Avenue, New York 18, N.Y.

Foreword

The Water Purification Division of the American Water Works Association, acting in its field of routine activities, in 1932 organized a committee to develop specifications and methods of testing zeolites used in water treatment. A "Tentative Manual of Zeolite Test Procedures" was approved and published in 1943. The committee has been continued under the chairmanship of D. E. Davis and in 1948 submitted a series of revisions to the text of the Manual. The title of the earlier document has been changed to: "Tentative Manual of Cation Exchanger Test Procedures."

The committee feels that, since the main body of the Manual has been used quite extensively in the trade and has been sufficiently discussed, its acceptance as a permanent standard is warranted. Items about which opinion is still in a state of flux, however, have been included as an Appendix to the document.

Personnel of Committee

D. E. Davis, *Chairman*
D. E. Chase
H. M. Olson
M. J. Shoemaker

Technical Advisory Committee

A. S. Behrman
E. S. Hertzog
F. K. Lindsay
E. R. Mueller
Oliver C. Ralston
H. L. Tiger

The above committee has the counsel of a technical advisory group (listed below), made up of representatives of the producers of the various types of zeolites and special chemical consultants.

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A. M. Buswell
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C. P. Hoover
H. E. Roush
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Tentative Manual of

Cation Exchanger Test Procedures

(Ion-Exchange Materials—Cation Exchangers Operating on the Sodium Cycle—Commonly Termed "Zeolites")

Section 1—Scope

Sec. 1.1—Sodium Cycle Only

The term "cation exchanger," as hereinafter used in this "Manual of Cation Exchanger Test Procedures," shall be taken to mean all granular cation-exchange materials operating on the sodium cycle, for removing hardness (Ca, Mg, etc., or iron (Fe) or manganese (Mn) in solution) from a water supply, employing common salt (sodium chloride (NaCl)) as a regenerant. This manual deals with cation exchangers operating on the sodium cycle only.

Sec. 1.2—Anion Exchangers Excluded

Anion exchangers employing alkaline compounds such as hydroxides and carbonates as regenerants require separate test procedures which are not included in this manual.

Sec. 1.3—Cation-Exchange Materials

Cation-exchange materials may be classed as:

1.3.1. *Inorganic Materials (Siliceous):*

(1) Glauconite, or greensand (low capacity and high capacity)

(2) Precipitated synthetic gel (sometimes called wet process)

(3) Fused synthetic

(4) Clay group or "Bentonites"

(5) Miscellaneous

1.3.2. *Organic Materials:*

(1) Coal derivatives (made from coal, lignite, peat (humus-containing), etc.)

(2) Resins

(3) Miscellaneous

Sec. 1.4—Object of Tests

The object of the tests herein described is to determine, as nearly as possible, the physical and chemical properties of exchangers by the use of laboratory methods, keeping in mind the necessity of correlating laboratory tests with actual performance of exchangers in service. It is recognized that laboratory tests do not indicate the quality of an exchanger over a period of time and under definite conditions of service as reliably as does experience.

Sec. 1.5—Limitations of Tests

The tests are only an indication of apparent results (comparative in nature), with actual operating results to be determined (as far as exchange capacity, in grains or kilograins, is concerned) by properly regulated acceptance tests to be determined in each case, preferably after the material has been properly conditioned or normalized—(1) at the beginning of operations and (2) at the end of a week or a month or any other suitable period.

Section 2—Suggested Definitions

Sec. 2.1—Zeolite

A zeolite is defined as any member of the family of hydrous silicates

(aluminosilicates), such as the phillipsite, the montmorillonite or the natrolite groups (which are so called because many species intumesce before the blowpipe) and some clay minerals, ultramine, glauconite and chabazites. A smaller degree of ion exchange is found in feldspars and kaolinite. All of these minerals contain alkali or alkaline earth metals, and it is these metals which will ionize and exchange with ions in solutions. They are considered as analogous to the feldspars in chemical constitution. Since the original designation of zeolites, it has been found that organic materials as well as inorganic materials can be used to produce cation-exchange materials. There is no scientific justification for using the term "zeolite" to designate any of the cation-exchange materials in use today. Some thirty or forty years' use of the word "zeolite," however, has identified it so closely with base exchange and cation exchange in general, that the term is now generally accepted as covering both base-exchange and cation-exchange substances.

Although there has been no serious objection to extending the use of the word "zeolite" from the mineralogical field to the field of water treatment because of the similarity between the cation-exchange reactions of these minerals in nature to the reactions of the cation exchangers in water treatment processes, the increasing deviation of the composition of cation exchangers from the zeolitic minerals makes it desirable to use the more precise term "cation exchanger."

Sec. 2.2—Cation

The cation is the positively charged particle, or ion, in an electrolytic solution which travels to the cathode (a metallic ion and H^+) and, after being discharged, is evolved or deposited; hence it is any positive ion.

Sec. 2.3—Cation Exchange

Cation exchange is the property of exchanging a cation existing in a solid (cation exchanger) for another cation in solution. Exchange reactions are reversible and are used to a great extent in the field of water treatment.

Sec. 2.4—Anion

In an electrolytic solution, the anion is the negatively charged particle, or ion, which travels to the anode; hence it is any negative ion.

Sec. 2.5—Ion Exchange

Ion exchange is a reversible interchange of ions between a liquid phase and a solid (cation exchanger) involving no radical change in the structure of the solid.

Section 3—Suggested Terminology

Sec. 3.1—Samples

The procedures outlined in *Standard Method for the Examination of Water and Sewage* * [hereinafter called *Standard Methods;* all page numbers refer to the ninth edition] re: "Collection of Samples" (page 1) are suggested for sampling, preservation, etc., of any water to be tested according to the directions contained in this manual.

Sec. 3.2—Reports

The procedure outlined in *Standard Methods* re: "Expression of Chemical Results" (page 5) is suggested for reporting quantity determinations on any water tested according to directions contained in this manual. (*See also* footnote, page 468 of this manual.)

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* *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).

Sec. 3.3—Supplemental Reports

This form of report may be supplemented by customarily accepted methods of stating mineral analyses of water.

Section 4—Taking of Samples

Sec. 4.1—Representative Samples

The importance of obtaining a truly representative sample cannot be overemphasized. A sampling tube (Fig. 1) or a grain sampler * shall be employed in obtaining a representative sample, care being exercised to secure a full cross section, so that the effects of automatic sizing or segregation are taken into account.

Sec. 4.2—Samples for Shipping

If the material is shipped in containers, samples shall be taken from at

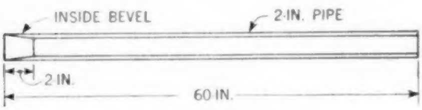


FIG. 1. Sampling Tube

least 5 per cent of them, scattered throughout the entire shipment. If the material is shipped in bulk, samples shall be taken from top, half way down and bottom from at least sixteen locations in the car. Samples from operating tanks or units shall total at least four samples per 100 sq.ft. of surface area, and in layers of lesser area a minimum of four samples shall be obtained.

These portions shall be mixed thoroughly into one composite sample of approximately 50 lb., then quartered or riffled to approximately 15 lb. of greensand or 9 lb. of synthetic or organic exchanger and immediately placed in an airtight container.

* Grain Sampler No. 12, $\frac{7}{8}$ in. in diameter, as made by Eimer & Amend Co., is suggested. Either dry or wet samples can be obtained. This grain sampler consists of two revolving concentric tubes with suitable annular openings, the inner tube being provided with knobs for rotating purposes.

Sec. 4.3—Air-Drying Not Recommended

Air-drying is not recommended, since exchangers, particularly the organic types, vary greatly in water content, even when in equilibrium with "air," and the density (apparent) is markedly influenced by the water content. When the tests for moisture, density and porosity have been determined by the procedures later described, it is believed that the assembled data will make it possible to compare exchangers on a convenient and practical basis.

Sec. 4.4—Draining for Sampling

To obtain, with the sampling tube (Fig. 1), a sample that will contain material from the entire depth of the exchanger layer, the water shall be drained from the entire exchanger layer down to the level of the top part of the supporting gravel layer. The sampling tube shall be driven into the drained layer.

Great care shall be exercised in rewetting the exchanger to remove air pockets by opening valves slowly, to fill the unit from below.

Section 5—Amount of Cation Exchanger for Tests

The approximate amounts of glauconite or greensand (at approximately 90 lb. per cubic foot) required for the various tests to be made according to these procedures are given in Table 1. Amounts of other exchangers shall be in the ratio of their dry weights to that of greensands.

TABLE 1

Amount of Exchanger for Tests

Test	Weight
	g.
Total moisture	3
Weight after backwashing	1,550
Sieve analysis	200
Exchange value	*
Chemical composition	10
Total	1,763

* Exchange value tests may be run on same sample as weight-after-backwashing tests.

or thickened at the ends it will prove more sturdy.

Sec. 6.2—Calibration Procedure

A rubber stopper of proper size, containing a piece of glass tubing approximately ¼ in. in diameter, with the end flush to the small end of the stopper, shall be prepared. To the long end, a short piece of rubber tubing shall be attached. A "Hoffman" screw clamp shall be used to regulate or to shut off flow. The rubber stopper shall be taped in place, for the weight of the layer of cation-exchange material is sufficient to loosen it. In mounting the tube, the bottom shall rest on a suitable support, and the tube shall be truly vertical, to prevent un-

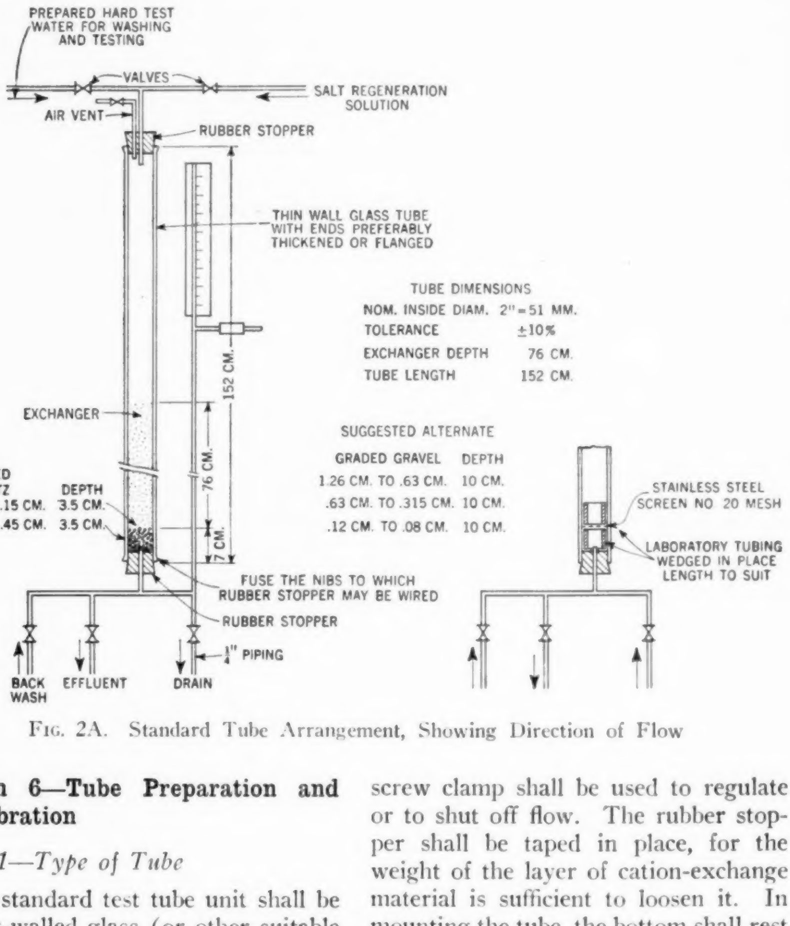


Fig. 2A. Standard Tube Arrangement, Showing Direction of Flow

Section 6—Tube Preparation and Calibration

Sec. 6.1—Type of Tube

The standard test tube unit shall be of light-walled glass (or other suitable material), with dimensions as shown in Fig. 2A. If the glass tube is flanged

desirable turning of the layer of exchanger.

On the bottom shall be placed 0.63 cm. graded quartz or suitable silica gravel (dirt- and oil-free), round and clean, to a depth of about 3.5 cm. and, on top, 0.315 cm. graded material to a depth of 3.5 cm. All of this material in place shall be washed by upflow until it is clean.

The tube shall be filled with water at 70°F. ± 10°F. (21°C. ± 6°C.) A height of 76 cm. above the quartz layer shall be measured with exactness, marking both top and bottom of the 76-cm. length; then the water shall be drained down to the top mark. Following this, the water between the top and bottom marks shall be drained into a graduate, measuring carefully the volume of water between the two marks.

Assuming that the measured volume equals 1,550 ml. and that 1 ml. = 0.0000354 cu. ft., then 1,550 ml. = 0.0548 cu. ft. occupied by 76 cm. in height. On this basis $\frac{0.0548}{2.5} = 0.02192$ sq. ft. equals the average area in the 76-cm. layer. The tube shall be permanently marked to show its area when the determination has been made.

Details of Fig. 2A tube arrangements are shown in Fig. 2B.

Sec. 6.3—Calibration of Entire Tube for Organic Cation Exchangers

For those exchangers in which the volume changes during the operation cycle, it may prove desirable to calibrate the entire tube by attaching a strip of graph paper,* ½ in. wide, along the axis of the tube. Calibration may be made by successive additions of water (10 ml.) from the burette, with volumes marked on the graph in convenient units. In such case, the "volume" factor shall be marked on the tube.

Sec. 6.4—Various Test Tube Diameters

Test tubes having a diameter other than that herein designated are being used, but it is felt that the diameter chosen will permit reasonably accurate and reproducible results with a minimum of sample (material) and test water requirements.

Section 7—Air-Drying

Sec. 7.1—Limitation

It is to be noted that under Sec. 4.3 air-drying is not recommended. Certain tests covered in this manual, however, state that air-drying of samples is a permissible procedure if reproducible results can be obtained. Therefore, a suitable air-drying procedure is given.

Sec. 7.2—Air-Drying Procedure

To insure reproducible results when air-drying materials, the following procedure shall be used:

The sample shall be spread over the bottom of a suitable container to a depth of ½ in. Drying shall continue for 24 hr. and shall be facilitated by thorough mixing and spreading of the sample three times, at intervals of eight hours, for the organic materials. Twice the time and number of stirrings shall be employed for inorganic materials. On completion of the sieve analysis, the moisture content of the sample shall be determined. (*See* Supplementary Notes, p. 478.)

Sec. 7.3—Moisture and Density

The total moisture of this sample shall be determined as in Sec. 10 (*see* p. 461) and the density of the dried material determined as in Sec. A1 of the Appendix (*see* p. 471). The density of

* 10 × 10 per ½ in., tenth lines heavy—equivalent to K & E No. 359-11.

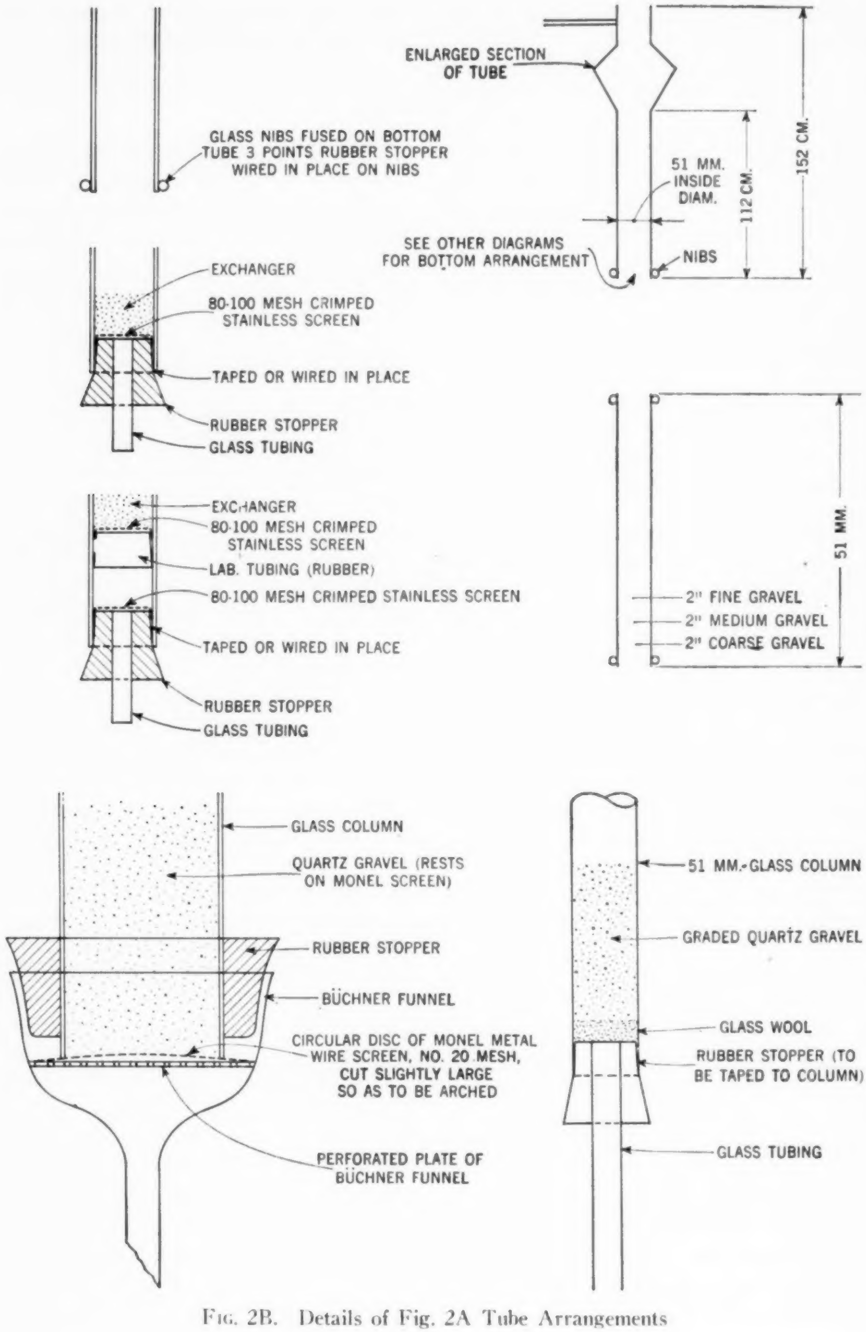


FIG. 2B. Details of Fig. 2A Tube Arrangements

the sample "as is" should be determined in a similar manner, and the "wet-down" density as indicated in Sec. A4.3 of the Appendix (*see* p. 477).

Section 8—Oven-Drying Procedure

When oven-drying is specified, the exchanger sample shall be dried to a constant weight in an oven capable of maintaining a temperature of 105° to 110°C.* It shall then be cooled in a desiccator before weighing. The exchanger shall be regenerated to its sodium form and rinsed before drying.

Section 9—Jarring or Shaking

Sec. 9.1—Mechanical Jarring and Shaking

To assure the maximum of uniformity in results when jarring is specified, jarring shall consist of vibrating the sample and container for one minute on a mechanical shaker at 150 taps per minute, and shaking shall be for a three-minute period. (Organic materials require a longer shaking period, but no precise time which will be correct for all can be given.) A 5 per cent speed tolerance is allowable.

The "Ro-Tap Testing Sieve Shaker," manufactured by W. S. Tyler Co. of Cleveland, Ohio, and the portable "Clenco-Meinzer Sieve Shaker," manufactured by the Central Scientific Co. of Chicago, are acceptable types of mechanical equipment.

Sec. 9.2—Manual Jarring

The container can be jarred by hand until there is no appreciable settling of the cation exchanger; then more material is added to fill the container to total capacity, with additional jarring to be sure that the measuring container is full.

Sec. 9.3—Manual Shaking

In manual shaking, the nest of sieves containing the sample shall be rocked back and forth over a piece of wood so that the bottom of the pan is about 1 in. above the table top. The rocking shall be at the rate of 150 bumps per minute (75 on each side), bumping the entire nest against a wood table for five minutes. Sieves shall be bumped lightly and not bounced. Heavy bouncing will produce erratic results.

Section 10—Total Moisture in Cation Exchanger as Received

Sec. 10.1—Apparatus

The apparatus required consists of: (1) one 2-in.-diameter standard weighing bottle (stoppered); (2) a drying oven capable of maintaining a temperature of from 105° to 110°C.; and (3) an analytical balance and desiccator.

Sec. 10.2—Procedure

The weight of the weighing bottle and stopper shall be determined. About 3 g. of material shall then be placed quickly in the weighing bottle and the bottle sealed immediately with the stopper. The bottle and sample shall be weighed. Then the stopper shall be removed and the bottle placed in the oven, maintained at 105° to 110°C. It shall then be dried for twelve hours, or to constant weight. For calculation of moisture, the following equation may be used:

$$\frac{\text{Loss in wt.}}{\text{Wt. of sample}} \times 100 = \%\ \text{moisture as received}$$

* Construction details of an oven satisfactory for this procedure are given in an article entitled "A Temperature and Humidity-Controlled Dryer for a Chemical Engineering Laboratory," by ROBERT M. SCHAFFNER & JAMES COULL of the University of Pittsburgh (Ind. Eng. Chem.—Anal. Ed., **14**: 590 (1942)).

NOTE—Synthetic (inorganic) exchanger loses its water of hydration at 105° to 110°C., and the moisture is not returned on atmospheric cooling; thus, after this test, the sample should be thrown away, as its exchange value is affected. Resinous exchangers can be brought back to exchange capacity but may crumble.

Sec. 10.3—Moisture in Air-dried Sample

Moisture in the air-dried sample is to be determined by the total-moisture method.

Section 11—Weight per Cubic Foot of Cation Exchanger as Received

Sec. 11.1—Apparatus

The apparatus required consists of: (1) small platform scales, weighing in pounds and ounces; and (2) a 1-cu.ft. box (preferably with rigid sides), wood or steel. This box shall be made to fit a "Ro-Tap," or equal, shaking machine so that reproducible results can be obtained.

Sec. 11.2—Procedure

The box shall be weighed to the nearest ounce, then quickly filled to overflowing with test material, just as received in the sample shipping containers. The box shall then be jarred (*see* procedure under Sec. 9) and the excess material stricken off the top of the box with a suitable straight edge. The box and test material shall then be weighed to the nearest ounce. The total weight minus the weight of the box gives the weight of the exchanger per cubic foot, as received.

NOTE—The box can be jarred by hand until there is no appreciable settling of the material, and then additional material can be added to fill it to total capacity, with additional jarring to be sure the measuring container is full.

Section 12—Weight per Cubic Foot of Saturated Settled Cation Exchanger After Backwashing

Sec. 12.1—Apparatus

The apparatus required consists of: (1) one softener unit (glass tube) as shown in Fig. 2A and 2B; and (2) a balance sensitive to 0.5 g. in 100 g.

Sec. 12.2—Procedure

A sufficient amount of the regenerated exchanger sample to make a layer approximately 76 cm. deep shall be weighed accurately. About 76 cm. of water shall be placed in the tube and the regenerated exchanger poured slowly into the water. If the exchanger tends to swell, it shall be checked at intervals until the swelling has ceased. The material shall then be backwashed in an upward direction for 20 minutes with clear tap water at a rate sufficient to give 50 per cent expansion of the exchanger layer, uniformly maintained for fifteen minutes.

The backwash shall be decreased slowly for the last two minutes, and, when stopped, the effluent valve shall be opened so that water is drained off at the average rate of 12 cm. per minute. The operation shall be stopped with 0.63 cm. water above the top of the sand, and the volume (in cubic feet) of the saturated layer of regenerated exchanger measured. (Care should be taken to avoid shaking or tapping the tube when making volume measurements and to prevent quiescent settling between backwashing and draining.) On this basis:

$$\frac{\text{Wt. of exchanger (in lb.)}}{\text{Vol. of satd. exchanger (cu.ft.)}} = \text{Wt. of ex-}$$

changer as received (in lb./cu.ft.) in position in softener

and:

$$\frac{\text{Wt. of exchanger } (100 - \% \text{ moisture})}{100 \times \text{cu.ft. of satd. exchanger}} = \text{Wt. of exchanger per cu.ft. (dry basis)}$$

Three separate tests should be conducted and the average result reported.

Section 13—Sieve Analysis of Cation Exchanger

Sec. 13.1—Apparatus

The apparatus required consists of: (1) sieves; (2) one sieve pan; (3) one sieve cover; and (4) a balance or scale sensitive to 0.1 g. in 300 g.

TABLE 2

Standard Specifications for Sieves for Testing Purposes

Sieve No.	Openings—*mm.* ASA Std.	Tyler
8	2.38	2.36
10	2.00	—
10	—	1.65
16	1.19	—
20	0.84	0.833
30	0.59	0.589
40	0.42	0.417
50	0.297	0.295
60	0.250	—
65	—	0.208

The sieves are to be 8 in. in diameter, square mesh, having ASA Standard sieve openings or the corresponding Tyler standard sieve openings. Sieves shall meet the requirements of the ASA specifications document Z23.1-1939, as shown in Table 2.

Sec. 13.2—Procedure

A sample of air-dried material, of a weight as follows, shall be taken:

For materials bulking approximately:

25 to 40 lb. per cu. ft.—	50 grams
40 to 65 " " " "—	100 grams
65 to 95 " " " "—	200 grams

In the sieve analysis of synthetic exchangers extreme care must be exercised in removing the material from the sieves for weighing, as it has a tendency to bounce and thereby be lost. This causes low results and makes it impossible to check within the tolerance required. It is recommended that the sieves be cleaned and all weighing be made over a black surface.

For materials which swell when wetted, similarly conducted tests shall be made on oven-dried material, a fully swollen sample, a wet-screen analysis and a sample "as received," if possible.

For synthetic or coarse-grained exchangers, sieves No. 8, 10, 16, 20, 30, 40 and 50 shall be used.

For organic exchangers and greensand, sieves No. 10, 16, 20, 40, 50 and 60 shall be used.

The material shall be shaken for 3 minutes in a mechanical shaker or for 5 minutes manually (*see* Sec. 9.3).

Sec. 13.3—Reporting Results

The sieve analysis shall be reported in percentage by weight to the nearest 0.1 per cent retained on the various sieves, and the result preferably plotted on logarithmic paper. Following is an example of a proper form of report:

	per cent
Retained on No. 8 sieve	—
Passing No. 8 and retained on No. 10	—
" No. 10 " " " No. 16	—
" No. 16 " " " No. 20	—
" No. 20 " " " No. 30	—
" No. 30 " " " No. 40	—
" No. 40 " " " No. 50	—
" No. 50 " " " No. 60	—
" No. 60 " " " No. 65	—
" No. 65 " " " pan	—
Total........................	—

(Specify sieve used—ASA Std. or Tyler)

If the percentages do not total 100, correction shall be made on the largest quantity retained on any sieve. If the sum of the weight retained on each sieve and that which passes the smallest

size sieve is less than 99 or more than 101 per cent, however, the test shall be discarded and another test made.

NOTE—Different screen fractions will contain a different percentage of moisture due to their difference in grain sizes and the lack of time to approach a uniform moisture condition of the exchanger. After the quick air-drying operation, the sample should preferably be held in a sealed jar overnight so that the moisture content may become uniform throughout.

Section 14—Resistance of Cation Exchangers to Aggressive Attack

Although no definite test procedures are included here, various laboratories will have the occasion from time to time to test two or more cation exchangers on a comparative basis. For assistance in planning such tests, the following factors are suggested for consideration:

pH: Both high- and low-pH conditions have been reported as having an aggressive effect upon the siliceous cation exchangers. High pH also appears to have an aggressive effect upon certain of the organic cation exchangers.

Temperature: High temperatures in particular are destructive to many cation exchangers.

Iron: The content of a water being treated has a significant effect upon the life of the cation exchanger, particularly those exchangers which are not susceptible to cleaning by acid.

Free Carbon Dioxide: Siliceous exchangers in particular are susceptible to aggression by waters containing free carbon dioxide.

Silica: Low-silica waters are aggressive toward siliceous cation exchangers.

Chlorine: Aggressive attack by chlorine is particularly important in organic cation exchangers.

Concentrated Brine: Inorganic cation exchangers are sometimes affected by too concentrated brine.

Section 15—Determining Exchange Values of Cation Exchangers

This method of test comprises the determination of the operating exchange or capacity value (sodium cycle) of cation exchangers and not the total exchange, because, in practice, it is not customary to operate cation-exchange softeners until they are completely exhausted, but to operate only to a definite hardness endpoint.

Sec. 15.1—Apparatus

15.1.1. *Test Unit:* A standard calibrated test unit (Fig. 2A, 3, 4) shall be used. Attachments to the tube shall be made so that the softener tube can be used for upward or downward flow. A means of regulating the rate of flow of the backwash and effluent shall be provided.

15.1.2. *Receivers:* Any calibrated container may be used as a receiver.

15.1.3. *Test Bottle:* A 100-ml. rubber-stoppered bottle shall be used.

Sec. 15.2—Synthetic Test Water

A supply of synthetic test water (25 gal.) shall be made up as follows:

15.2.1. *Solution 1* (for synthetic, resinous and carbonaceous exchangers):

400 ppm. Total Hardness (as $CaCO_3$)
$CaCl_2$ (anh.)....1.115 g./gal.,* or 0.296 g./l.*
$MgSO_4 \cdot 7H_2O$...1.251 g./gal., or 0.332 g./l.

15.2.2. *Solution 2* (for greensand):

170 ppm. Total Hardness (as $CaCO_3$)
$CaCl_2$ (anh.).....0.473 g./gal., or 0.126 g./l.
$MgSO_4 \cdot 7H_2O$.....0.530 g./gal., or 0.141 g./l.

* In these abbreviations, as elsewhere, the "g." stands for gram, *not* grain.

15.2.3. *Solution 3* (for high-capacity exchangers):

300 ppm. Total Hardness (as $CaCO_3$)
$CaCl_2$ (anh.)..... 0.835 g./gal., or 0.199 g./l.
$MgSO_4 \cdot 7H_2O$..... 0.936 g./gal., or 0.248 g./l.

Sec. 15.3—Natural Water

When the tests are made on a natural water, its hardness and composition shall be accurately determined.

Sec. 15.4—Salt Solution

15.4.1. *Quantity:* 1 gal. of 5 per cent cp. salt solution shall be used. Table 3 summarizes the volumes of 0.855 *N* sodium chloride (5 per cent) used for sodium exchangers of different types for this standard laboratory test. The quantity may be varied, however, for particular tests.

15.4.2. *Quality:* The salt (NaCl) should not contain more than 2 per cent Ca and Mg salts, expressed as sodium chloride; and the analysis of the salt used shall be stated.

15.4.3. *Strength of Solution:* Salt solution shall be made from tap water to a strength of 0.855 *N* (5 per cent) by weight of salt (NaCl).

15.4.4. *Temperature:* The water and brine temperature during exchange value tests shall be 70°F. ± 10°F. (21° ± 6°C.).

15.4.5. *pH:* Hard water (tap) shall be used for making the brine. The pH value of the brine shall be above 7.0, but not more than 8.3. The pH value shall be recorded.

Sec. 15.5—Soap Solution

15.5.1. *Standard Palmitate Soap Solution:* Standard potassium palmitate soap solution made according to *Standard Methods* (page 23) shall be used in all determinations where an issue exists concerning the acceptance of exchangers or their conformance to specifications.

15.5.2. *B&B Soap Solution:* Soap solution made according to Boutron-Boudet (*Standard Methods* Zeolite Softener Field Test, *eighth* edition, page 103), when calibrated against standard potassium palmitate soap solution, may be used in field or routine testing of performance of exchangers, but it shall not be used as a basis of acceptance or rejection of exchangers.

TABLE 3

*Brining of Exchangers**

Cation Exchanger	Brining and Displacement Time‡ *min.*	Nom. Exchange Capac., *grains per cu.ft.*	Salt		Vol. 0.855 *N* NaCl (5%) required for 1,550-ml. unit *ml.*
			lb./cu.ft.	*me./l.*§	
Greensand	35	2,800	1.26	0.347	604
High-capac. greensand	45	5,500	2.47	0.681	1,188
Synthetic siliceous	60	11,000	5.27	1.45	2,520
Coal derivatives	60	7,000	3.15	0.87	1,507
Resin, phenolic polystyrene† base	60	7,000–35,000			

* Salt shall be applied at the rate of 0.45 lb. per kilograin of hardness removed. If salt economies are to be stressed, lower salt doses may be employed, but at lower exchange capacities, as guaranteed by the manufacturers.
† Because of limited experience with this material, it is suggested tentatively that a 15 per cent sodium chloride solution shall be used.
‡ The displacement rinse is a volume of raw water applied at the same rate as, and following, the brine and is used for rinsing the brine from the exchanger so that all parts of the exchanger shall receive equal contact with the brine.
§ *See* footnote, p. 468.

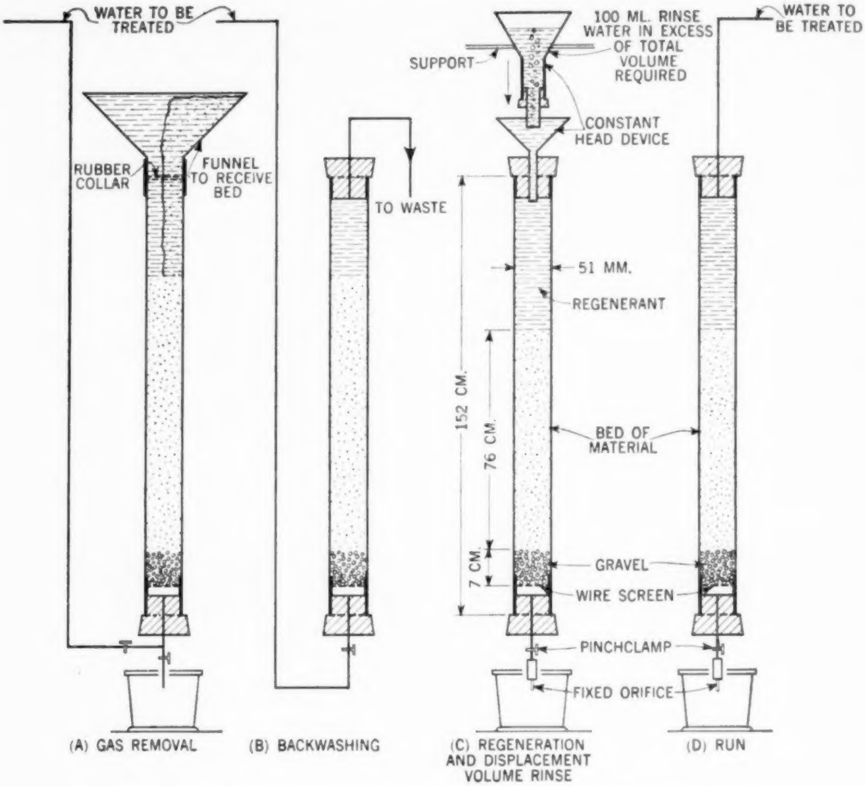


FIG. 3. Tube Arrangement for Exchange Capacity Determinations

Sec. 15.6—Volume

An amount of the sample in excess of that apparently required to give a 76-cm. layer of the regenerated exchanger shall be weighed out. The procedure of Sec. 12.2 shall then be followed to place the sample in the water up to the 76-cm. mark. The unused portion shall be weighed and (by difference) the weight in the tube recorded. Materials that swell shall be permitted to stand until swelling has ceased. The procedure of Sec. 12.2 shall then be followed to determine the volume. Tests shall be repeated until consistent results are obtained; and values shall be recorded.

It will be permissible to add or subtract material to adjust the exchanger volume at exactly 76 cm. when backwashed and drained. The gross weight and net dry weight of the 76-cm. bed shall be calculated in terms of the relative volumes.

Sec. 15.7—Preliminary Treatment

Many cation-exchange materials are placed on the market in an alkaline condition so that it is necessary to remove this free alkali by repeated backwashings and downflow operations before starting the test. Excessive amounts of alkali affect the exchange capacity and therefore give false results. To

determine when the free alkali has been removed, a fifteen-minute soaking test with the water to be softened shall be made. In this test, the hydroxide alkalinity of the water standing in the exchanger layer during the soaking period, when drained off, shall not exceed 3 ppm. Following this thorough removal of free alkali, the exchanger shall be given two or three successive regenerations with salt (NaCl) to insure complete removal of calcium and magnesium salts. The regular test runs may then be started, but it will be necessary to discard the first few runs, which will probably be abnormally long. The result of these initial runs shall be recorded, but shall not be considered as representative until fairly constant results are obtained on several runs under a given set of conditions.

Sec. 15.8—Backwashing Operation

15.8.1. *Arrangement:* The rubber connections for backwashing shall be as shown in Fig. 4. At the end of each softening run, the exchanger layer shall be backwashed thoroughly to cleanse and loosen it. The water to be treated shall be used to backwash. The flow rate during backwashing shall be sufficient to expand the material approximately 50 per cent, and the period of washing shall be long enough to remove all dirt collected in the tube or in the layer during the softening run. The backwash time shall usually be about five to ten minutes; the time shall be recorded.

15.8.2. *Gas Removal:* If a considerable amount of air or gas collects in the layer during the run, it will be necessary to employ special means to remove such entrained gases before proceeding with the normal backwashing operation. The layer shall be backwashed into a large funnel, connected to the top of the tube with wide rubber tubing as shown in Fig. 3 (A). Then the layer shall be allowed to return to the tube by draining all of the material from the funnel back into the tube, after which the backwashing procedure described in Sec. 15.8.1 shall be followed.

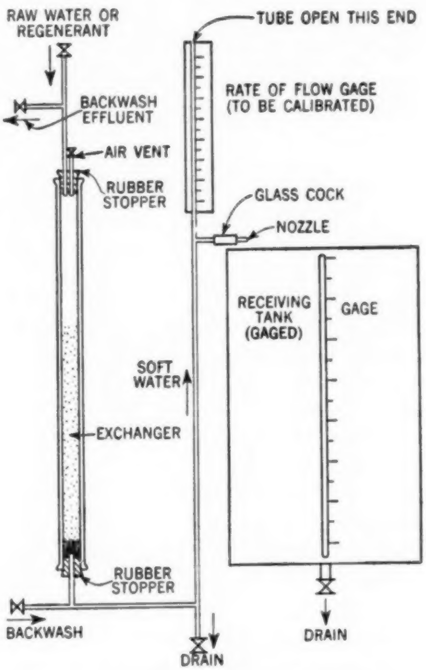


Fig. 4. Calibrated Tube Arrangement for Exchange Capacity Determinations

Sec. 15.9—Regeneration Operation

15.9.1. *Brine Introduction and Displacement Volume Rinse:* The tube connections and constant-head device for regeneration and rinse are shown in Fig. 3 (C). After backwashing, the tube shall be drained until the water level is about 1 cm. above the top of the layer. The tube shall be filled with regenerant to the point where it is just possible to fit the narrow-stem funnel

into the top of the tube with a rubber stopper. The remainder of the regenerant shall then be poured into the funnel.

A fixed orifice or capillary tube shall be placed at the bottom of the tube and the clamp on the outlet opened so as to give a flow rate of 40 ml. per minute. The bottle containing the rinse water shall then be placed in position. Regenerant and water shall be allowed to flow until the regenerant and displacement water have passed through the exchanger layer.

It is advantageous to have a mark on the tube 100 ml. above the surface and to have 100 ml. of rinse water in the bottle in excess of that required for rinsing, so that the flow can be stopped when this top mark is reached. This avoids the possibility of introducing air into the top of the exchanger layer by attempting to stop the flow of water exactly at the surface.

15.9.2. *Insufficient Volume of Regenerant:* When the volume of regenerant is insufficient to fill the tube completely above the layer, it is advisable to attach a rubber tube to the bottom of the funnel, so that the end will dip slightly into the regenerant. Then the subsequent procedure shall be similar to that described in Sec. 15.9.1.

15.9.3. *Quantities of Brine Used for Regeneration:* The quantities of brine solution to be used for the initial regeneration of sodium exchangers are shown in Table 3.

15.9.4. *Composition of Rinse Water:* The composition, temperature, pH, etc., of the rinse water shall be the same as that of the water to be treated.

15.9.5. *Volume of Rinse:* The rinse volume (displacement volume) shall be passed through the exchanger layer at the same rate as the regenerant. After the displacement volume has passed through the test material, the fixed orifice shall be removed from the outlet line. Another fixed orifice, giving a flow rate of 250 ml. per minute, shall then be inserted, and at the same time the top of the tube shall be connected to the influent water line, as illustrated in Fig. 3 (D). The flow of water through the material shall be continued until the hardness can no longer be maintained at 10 ppm. (as $CaCO_3$), using *Standard Methods* palmitate soap solution. This point shall constitute the end of the rinsing operation and the start of the softening run.

Sec. 15.10—Softening Run

15.10.1. *Starting Point:* The hardness of the effluent at the standard *starting point* of a run shall be 10 ppm. (as $CaCO_3$), using *Standard Methods* palmitate soap solution.

15.10.2. *Flow Rate and Exchange Velocity:* The standard flow rate shall be 250 ml. per minute, which corresponds to 12.2 ml. per square centimeter per minute, or 3 gpm. per square foot. The exchange velocity shall be 2.14 me./l.* per minute or 0.0466 grains per cubic foot per minute, when softening a water with a hardness of 8.55

* The unit "equivalents per million grams" (epm.), tentatively approved by the American Society for Testing Materials in 1940, appears to be more consistent when used together with the firmly established "parts per million" (ppm.), because each is a "weight per weight" unit. The abbreviation "epm.," however, introduces a serious inconsistency in that the letter "m" stands for "million grams" rather than for "million equivalents" as might be inferred from its significance in the term "ppm." Because of this, and also because, in the use of weight per weight units, it is not always clear whether weights of solution or weights of solvent are meant, the Cation Exchanger Manual Committee prefers to use the weight per volume units, i.e., milligrams per liter (mg./l.) and milligram equivalents per liter (me./l.).

me./l. (25 grains per gallon, or 428 mg./l.). Proportionate corrections should be made according to the area of the tube used.

15.10.3. *Endpoint:* The hardness of the effluent at the standard *endpoint* of a run shall be 16 ppm. (as $CaCO_3$), using *Standard Methods* palmitate soap solution.

15.10.4. *Composition of Effluent:* In addition to checking the hardness of the softened effluent at frequent intervals throughout the run, it is essential also to check the pH value, methyl orange alkalinity, phenolphthalein alkalinity and free CO_2 at intervals, particularly at the start of a series of runs with new cation-exchange material.

Sec. 15.11—Calculation of Capacity

15.11.1. *Capacity in the Test:* The results of the individual test runs shall be recorded and, from the volume of water softened, volume of exchanger and hardness of water used during softening, the exchange capacity shall be calculated by the following equations:

$$\text{Capac. (me./l.)} = \frac{\text{Influent hardness (me./l.)} \times \text{Effluent (l.)}}{\text{Test material vol. (l.)}}$$

$$\text{Kilograins/cu.ft.} = \frac{\text{me./l.}}{45.8}$$

$$\text{Capac. (me./g.)} = \frac{\text{me./l.}}{\text{g. (105°C.) per l.}}$$

In special cases where appreciable hardness is present in the effluent, the calculations must be corrected for the residual hardness remaining in the softened water.

15.11.2. *Capacity as Received:* It is often desirable to test a shipment of exchanger when received, but before it is put in place. A convenient method of accomplishing this is to prepare a test layer in a piece of pipe of convenient diameter (preferably 6 to 8 in.) and with freeboard sufficient to allow at least 60 per cent exchanger expansion. The test model should be built with the same depth as its counterpart. The hard-water influent shall be metered and the effluent checked volumetrically. The methods described in Sec. 15.11.1 shall be followed, but the salt dosage should be that set forth in the specifications for the particular installation in question. (*See* Supplementary Notes, page 478.)

Section 16—Color Leaching Test

After making a number of exchange capacity runs in the sodium cycle, the exchanger shall be regenerated with 400 ml. 5 per cent brine (NaCl) solution. The brine solution shall be made to flow through the exchanger at 20 ml. per minute. The material shall then be rinsed with 400 ml. distilled water at 20 ml. per minute. Rinsing shall be stopped when the water level is 1.26 cm. above the surface of the test material. The water shall be allowed to stand in the unit overnight (preferably for sixteen hours), and then drained into a beaker for the color determination by the procedure of *Standards Methods* (page 14).

Section 17—Chemical Composition of Synthetic Siliceous Exchangers

Sec. 17.1—Sampling

The procedure for sampling of exchangers (Sec. 4) shall be followed.

Sec. 17.2—Preparation of Sample

About 10 g. of exchanger to be tested shall be washed in a strong salt solution (about 50 per cent saturation) and then washed with distilled water until free from chlorides. The material shall then be oven-dried (*see* Sec. 10.1). (An air-dried sample may be used if desired, making a correction in weight for the moisture content.) The

sample is then ready for chemical analysis.

Sec. 17.3—Determinations

17.3.1. *Loss on Ignition:* In a platinum crucible, approximately 1 g. of oven-dried sample accurately weighed shall be heated to a dull red heat for 20 minutes, then cooled in a desiccator and reweighed. The percentage loss on ignition on the oven-dried sample then equals:

$$\frac{\text{Loss in wt.}}{\text{Wt. of sample}} \times 100$$

17.3.2. *Silica:* The exchanger shall be finely ground and about 0.5 g. of air-dried sample shall be weighed accurately and placed in a platinum or porcelain dish. The sample shall be moistened with distilled water, then 20 ml. of 6 *N* HCl shall be added and the sample evaporated to dryness on a steam or water bath. The procedure shall be repeated by adding an additional 20 ml. of 6 *N* HCl and evaporating to dryness a second time. The material shall then be dried at 105°C. for one hour. (*See* Supplementary Notes, page 478.)

The residue shall be redissolved with 5 ml. concentrated HCl followed by 50 ml. distilled water. Following this, the residue shall be filtered, using an ash-free paper, and washed free of HCl, saving the filtrate and washings. The filter paper and residue shall then be placed in a platinum crucible (not porcelain), dried, ignited at 950°C. to constant weight, cooled in a desiccator and weighed (first residue).

The contents of the crucible shall then be moistened with two drops of 1 : 1 sulfuric acid, followed by 5 ml. of hydrofluoric acid. The crucible shall be heated gently under the hood to expel the excess hydrofluoric acid, after which the heat shall be increased until all fumes of sulfuric acid have been expelled. The residue shall again be ignited at 950°C., cooled in the desiccator and weighed (second residue). Then:

$$\frac{\text{Wt. of first residue} - \text{Wt. of second residue}}{\text{Wt. of sample taken}} \times 100 = \%\ \text{Silica in air-dried sample}$$

The final residue in the crucible shall then be dissolved by fusing with a little potassium bisulfate and dissolving in a little dilute H_2SO_4. This solution shall then be added to the original filtrate and washings and used for the determination of alumina.

17.3.3. *Alumina:* The alumina determination shall be made as follows:

To the solution, evaporated to approximately 100 ml. and free from phosphoric or arsenic acid and elements that would precipitate with aluminum, shall be added 5 g. NH_4Cl and 5 ml. concentrated HNO_3. The solution shall then be heated to boiling and allowed to cool. To the cooled solution shall be added two or three drops of an indicator with a pH range of 6.5–7.5. Then, dropwise, very carefully, from a burette, shall be added NH_4OH (dilute 1 : 1; free from carbonate) until the alkaline color is obtained (pH 7.5). The solution shall then be heated to boiling and filtered. The precipitate shall be washed with a 2 per cent solution of NH_4NO_3.

The precipitate shall be dissolved in a small amount of hot, dilute HCl and reprecipitated to eliminate, as completely as possible, occluded substances. It shall be ascertained that the solution of the hydroxide by HCl is complete and that the alkalinity in reprecipitation does not exceed the limit recommended.

The precipitate shall be washed free of chlorides, using the 2 per cent NH_4NO_3 solution, and then shall be drained. The filter and its contents shall be placed in a platinum or porcelain crucible and ignited, gently at first until the paper is thoroughly charred, at which time the heat shall gradually be increased. The crucible shall then be covered and heated to a glowing white temperature, cooled in a desiccator and weighed rapidly. The heating, cooling and weighing shall be repeated until a constant weight is obtained.

The precipitate shall then be weighed as alumina (Al_2O_3) unless a reddish tint indicates the presence of iron, in which case it shall be weighed as R_2O_3, determining the iron (Fe_2O_3) separately, and subtracting it from the R_2O_3 reading. (*See* Supplementary Notes, page 478.)

17.3.4. *Sodium Oxide:* Sodium oxide shall be determined on the basis that the sum of percentages (ignited-weight basis) of silica (SiO_2) plus alumina (Al_2O_3) and iron oxide (Fe_2O_3) subtracted from 100 equals the percentage of sodium oxide (Na_2O). Also sodium may be determined directly by any standard method of analysis.

17.3.5. *Moisture at 105°–110°C.:* Moisture shall be determined according to the procedure given in Sec. 10.

APPENDIX

Research Procedures

Section A1—Weight of Dry Cation Exchanger per Cubic Foot (Density Data)

Sec. A1.1—Apparatus

The apparatus required consists of: (1) one 1,000-ml. graduated glass cylinder; (2) a drying oven capable of maintaining a temperature of 105° to 110°C.; and (3) a balance, sensitive to 0.5 g. in 1,000 g.

Sec. A1.2—Procedure

A1.2.1. *Greensand:* The graduated cylinder shall be weighed. Oven-dried greensand shall be poured into the graduated cylinder to a little over the 1,000-ml. mark, shall be jarred (*see* procedure under Sec. 9.2), and operations shall be finished with exactly 1,000 ml. The cylinder and the greensand shall be weighed quickly. The difference in weight of the cylinder and the greensand and the empty cylinder is the weight of dry greensand in grams per 1,000 ml. Then:

Dry wt. per cu.ft. (in lb.)

$$= \text{Wt. (in g.) of 1000 ml.} \times \left(\frac{3.785 \times 7.48}{453.6}\right)$$

$$= \text{Wt. (in g.)} \times 0.0624$$

A1.2.2. *Other Cation Exchangers:* When resinous and carbonaceous exchangers are shipped dry (unwetted), an additional wetted weight per cubic foot of material shall be determined. To make this determination, the material shall first be immersed in water, i.e., thoroughly wetted. This wetting shall be such as to insure complete swelling of the particles. The material, after wetting, shall be drained to remove "free" water before it is placed in the test tube.

To make the results of this test reproducible it has been suggested that a "B&D" (backwashed and drained)

volume be used instead of a jarred volume.

The moisture content of all material to be tested shall be determined on duplicate average samples, by methods described in Sec. 10. This moisture content shall be recorded and reported.

Section A2—Determining Attrition Losses of Cation Exchangers

Accelerated tests thus far devised cannot be counted on to furnish completely reliable data concerning the probable life and operating characteristics of a cation exchanger placed in actual service. The tests have some value, however, in supplying comparative data which may be used as a guide. Suggested forms of tests have been prepared for the following materials: (1) greensand; (2) synthetic gels, fused synthetic, bentonites, miscellaneous; (3) carbonaceous and resinous exchangers.

Sec. A2.1—Scheme A—Greensand

A2.1.1. *Apparatus:* The apparatus required consists of: (1) one 4-oz. rubber-stoppered oil-sample or other bottle (about $1\frac{1}{2}$ in. in diameter by $6\frac{1}{2}$ in. overall); (2) one rotating shaking wheel (axis horizontal, to rotate at 17 rpm., with provision for connecting the bottle 1 in. from center of shaft (Fig. 5)); (3) one calibrated 1-liter volumetric flask; and (4) a Jackson turbidimeter.

A2.1.2. *Sampling:* Sampling shall follow the method of Sec. 4. If taken from an exchanger unit that has been used or is in actual use, samples shall be taken after regeneration.

A2.1.3. *Procedure:* 50 g. of air-dried regenerated exchanger shall be placed in the container, which shall then be filled with distilled water of approximately 70°F. temperature, and stoppered. The bottle shall be connected to the mixing wheel and revolved two hours at 17 rpm. The bottle shall then be removed and allowed to settle fifteen seconds, after which the supernatant liquid shall be poured into the 1-liter volumetric flask. The exchanger shall then be washed until the washings are clear.

After the washings have been collected in the volumetric flask, sufficient distilled water shall be added to fill the flask to the 1-liter mark, and these shall be mixed. The turbidity of the sample shall then be determined with the Jackson candle turbidimeter, to give a measure of the resistance to attrition in parts per million turbidity. Attrition value shall then be obtained as follows:

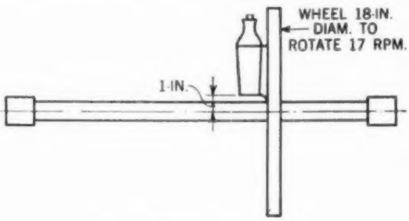


FIG. 5. Rotating Shaker

$$\text{Attrition value} = \frac{10{,}000}{\text{Turbidity (in ppm.)}}$$

Sec. A2.2—Scheme B—Synthetic Exchangers

A2.2.1. *Apparatus:* The apparatus required consists of: (1) a balance or scale (sensitive to 1 mg.); (2) a shaker ("Tyler Ro-Tap"); (3) one 5-oz. squat-form screw-cap jar; and (4) sieves.

A2.2.2. *Procedure:* From the air-dried sample that has not been previously shaken, a portion passing the No. 14 sieve and retained on the No. 20 sieve shall be sieved out. From this portion 20 g. shall be weighed out

accurately (on the dry basis). This material shall then be placed in the screw-cap jar and 75 ml. of distilled water at room temperature added. The jar shall then be capped and placed flat in the shaker pan and packed tightly with cloth or wadded paper. The lid shall then be placed on and the assembly clamped in the shaker. Shaking shall continue for two hours.

After shaking, the jar shall be removed and allowed to settle fifteen seconds. The liquid shall then be poured off into a 1-liter volumetric flask. To the exchanger in the jar about 75 ml. of water shall be added, the jar capped, turned over, the cap removed and the water poured into the flask. This procedure shall be repeated at least six times, after which the washings in the flask shall be made up to 1 liter, mixed and allowed to stand five minutes. Then 500 ml. shall be poured off.

Turbidity shall be determined by comparison with standards or by the Jackson candle turbidimeter. The greater the turbidity, the lower is the resistance to attrition.

Sec. A2.3—Scheme C—Carbonaceous and Resinous Exchangers

An alternate method has been designed for use with carbonaceous exchangers. Those interested are referred to the publication noted below.*

Section A3—Resistance of Cation Exchangers to Aggressive Attack

Tests used and proposed by technicians are so far removed from normal water softening plant operations that results may not only be meaningless, but quite misleading, and may have no particular significance in relation to the durability of the exchanger in different types of water.

For example, some waters are extremely low in silica; therefore the synthetic exchangers will not stand up, but will lose silica by dispersion. Distilled water in connection with such exchangers under standardized conditions will show pickup of silica from the exchangers. Other destructive factors occurring in water are, or may be, iron, manganese, variation of pH and high free CO_2. Therefore, tests should be devised to measure these destructive forces, but further laboratory work will be necessary before adequate tests can be announced.

The validity of the procedures hereinafter described is not yet fully established.

To record definite procedures that can be used for comparison purposes only, five methods are suggested: (1) for low-pH conditions; (2) for high-pH conditions; (3) for conditions encountering excess of concentrated brine; (4) for conditions encountering deficiency of silica; and (5) for conditions contributing to the breakdown of organic exchangers.

Sec. A3.1—Method A—Low-pH Conditions

A3.1.1. *Solutions:* (1) A buffered solution, with a pH of 4.0, shall be prepared by taking 50 ml. $M/5$ potassium acid phthalate ($KHC_8H_4O_4$) and 0.40 ml. $M/5$ sodium hydroxide (NaOH), and adding boiled and cooled redistilled water to make 200 ml. (2) A 5 per cent solution of cp. sodium chloride (NaCl) (for regenerating purposes). (*See* Supplementary Notes, page 478.)

A3.1.2. *Procedure:* After thorough regeneration of the sample (using So-

* Broderick, S. J. & Hertzog, E. S. Accelerated Tests for Determination of Attrition Loss of Carbonaceous Zeolites. Jour. A.W.W.A., **34**:94 (1942).

lution 2) and rinsing, the material shall be air-dried and about 15 g. shall be screened out to 30–40 mesh (U.S. Bureau of Standards). Moisture content shall then be determined (Sec. 10).

Duplicate samples of this air-dried material shall be weighed out, each sample weighing 1.0 g. net (calculated on dry basis after making allowance for moisture content). Each sample shall be placed in a 4-oz. rubber-stoppered oil-sample bottle (about 120 ml.) and filled with Solution 1. The bottles shall then be stoppered tightly and mounted on a rotating wheel, with the bottom of the bottles about 1 in. from the center. Rotation shall be for two hours at 17 rpm., with the room at 20° to 25°C. The supernatant liquid shall then be decanted and the residual material thoroughly rinsed with distilled water, being careful not to lose any of the exchanger grains. The washed material shall be transferred to a weighing bottle and shall be oven-dried and reweighed after the cooling. Finally, the percentage loss of weight on the 1.0-g. samples shall be calculated as percentage weight loss due to aggressive attack under the test conditions.

Sec. A3.2—Method B—High-pH Conditions

A3.2.1. *Solutions:* (1) A buffered solution, with a pH of 9.0, shall be prepared by taking 50 ml. $M/5$ boric acid (H_3BO_3), 50 ml. $M/5$ potassium chloride (KCl) and 21.30 ml. $M/5$ sodium hydroxide (NaOH) made up to 200 ml., and adding distilled water as described in Method A (Sec. A3.1.1). (2) A 5 per cent solution of cp. sodium chloride (NaCl) (for regenerating purposes).

A3.2.2. *Procedure:* The procedure described under Method A (Sec. A3.1.2) shall be followed.

Sec. A3.3—Method C—Conditions Encountering Excess of Concentrated Brine

A3.3.1. *Solutions:* (1) Boiled and cooled redistilled water. (2) A 25 per cent solution of cp. sodium chloride (NaCl) (for regenerating purposes).

A3.3.2. *Procedure:* The exchanger shall be regenerated with Solution 2, after which the procedure described under Scheme A (Sec. A2.1.3) subsequent to the end of the rotation period shall be followed.

Sec. A3.4—Method D—Conditions Encountering Deficiency of Silica

A3.4.1. *Solution:* (1) Boiled and cooled redistilled water. (2) A 5 per cent solution of cp. sodium chloride (NaCl) (for regenerating purposes).

A3.4.2. *Procedure:* The procedure described under Method A (Sec. A3.1.2) shall be followed to the end of the rotation period, except that the sample shall be placed in Solution 1. Pyrex glassware shall be used. The supernatant liquid and the rinsings of distilled water shall be decanted and saved. The silica in the liquid shall be determined and the loss from that of the original sample calculated.

Sec. A3.5—Method E—Conditions Contributing to Breakdown of Organic Exchangers

A3.5.1. *Solutions:* Buffered solutions shall be prepared in a manner similar to those shown in Methods A and B (Sec. A3.1.1 and A3.2.1), but with varying amounts of $M/5$ sodium hydroxide (NaOH) to give a range of pH values.

A3.5.2. *Procedure:* The exchanger samples shall be tested in these solutions, employing the procedure described under Method D (Sec. A3.4.2), except that the supernatants and rins-

ings shall be analyzed for dissolved organic matter, employing the oxygen consumed tests as described in *Standard Methods* (page 122). The loss shall be related to the total organic matter as run on a sample of original material.

Section A4—Porosity

No published data are as yet available to indicate a definite quantitative relationship between the porosity of different exchangers and their practical operational behavior. These procedures are included in order to make available a standardized basis upon which such characteristics of exchangers can be studied.

Sec. A4.1—Detailed Method

A4.1.1. *Pore Volume and Porosity:* The pore volume of a given quantity of granules can be expressed by the following equation:

$$\text{Pore Vol.} = \text{Exchanger Vol.} - \text{Void Vol.} - \text{Displ. Vol. of Solid} \quad (1)$$

and the porosity can be expressed as a percentage of the actual summation volume of the individual granules, excluding the void space between them, as indicated in the following equation:

$$\%\ \text{Porosity} = \frac{\text{Pore Vol.}}{\text{Pore Vol.} + \text{Displ. Vol.}} \times 100 \quad (2)$$

Unfortunately, it is difficult to define and measure some of the quantities on the right side of the equation.

A4.1.2. *Exchanger Volume:* The volume of the exchanger unit can be determined with a considerable degree of precision by several different techniques which give values over a range from a minimum dry volume to a backwashed and drained volume. The difference between these two extremes for materials that swell upon immersion may be as great as two- or threefold, and it becomes a matter of definition which reference state shall be selected in this large possible volume range.

A4.1.3. *Void Volume:* The volume of void space between the granules varies, of course, with the type of exchanger volume arrangement selected. It is also difficult to define the point at which fissures in the granules should be regarded as void space instead of pore space. Various techniques of distinguishing between the void space and pore space have been described in the literature, but the methods are complicated and are inevitably limited by the difficulties of definition.

A4.1.4. *Displacement Volume:* When the solid granules are immersed, the displacement volume is relatively easy to determine and remains constant regardless of the techniques used for defining the exchanger volume and the void space. A convenient apparatus for determining the displacement volume is shown in Fig. 6. To operate this apparatus, about 1½ to 3 times the amount of water necessary to immerse the sample of solid granules, whose displacement volume is to be measured, is first introduced into the large burette. All air bubbles below the water level are removed by raising and lowering the dropping funnel slowly two or three times. The level of water is then adjusted just at the bottom of the stopcock in the dropping funnel. The stopcock is then closed and the water level in the burette recorded. Next, the sample of granular material is introduced into the water in the burette. All air bubbles are removed again by raising and lowering the dropping funnel in such a way that a series of backwash treatments are carried out. This process is repeated over a period of time until consecutive readings of the final water

level in the burette become constant. In taking the readings of the water level plus the immersed solid, the level of the water in the dropping funnel is, of course, adjusted just at the base of the stopcock as in the initial measurement.

With such equipment, it is possible, with the single volume of water, to backwash a layer of granules until all the air bubbles have been removed. The displacement volume of the solid is given by the difference between the level of the water at the start and that at the conclusion of the backwashing process.

A4.1.5. *Quantitative Porosity Relationships:* No data are available to give quantitative relations between the porosity of different materials and their practical operational behavior. In general, the more porous materials are regarded as presenting a greater reactive surface to percolating solutions; hence, it would be expected that they would exhibit a higher capacity within a practical time limit. The more porous materials may, however, be more fragile and may undergo more serious disintegration in long-term operation. Similarly, the more porous materials are regarded by some as more subject to being rendered inactive because of clogging of the surfaces with fine particles of suspended solids. Hence, in addition to the difficulties of defining and determining porosity, there is some question even as to its theoretical significance in relation to practical operation of granular materials in percolation cycles.

A4.1.6. *Quantitative Porosity Measurements:* Of the various quantities related to porosity, the minimum dry volume (MDV) and the backwashed and drained exchanger volume (B&D Vol.) measurements and the displacement volume measurements can be

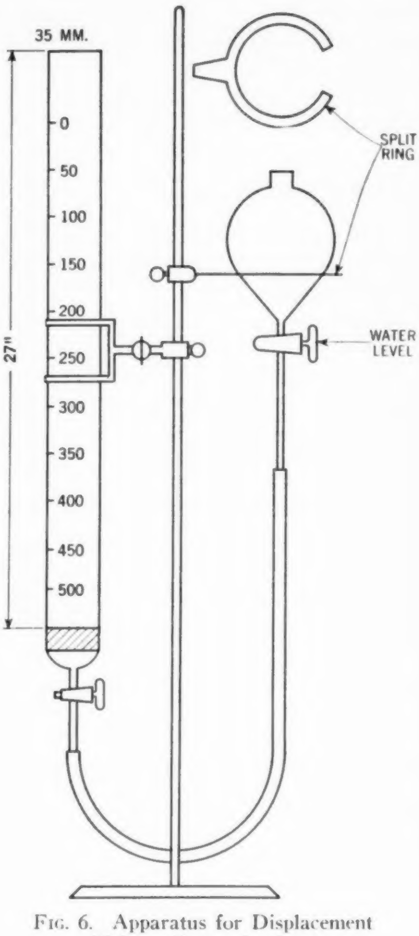


FIG. 6. Apparatus for Displacement Volume Determinations

made with the greatest facility and accuracy. Since uniformly sized granules of the same general character, in a given type of volume arrangement, possess the same void space, it seems likely that a given quantity of porous materials exhibits relatively small displacement volumes, e.g., a synthetic siliceous exchanger gave a displacement volume of 27 per cent of its minimum dry volume while relatively nonporous materials gave displacement volumes as high as 100 per cent of their

minimum dry volume. The two quantities can be described by the following equations:

$$\% \text{ Displ. Vol. (MDV)} = \frac{\text{Displ. Vol.}}{\text{MDV}} \times 100 \quad (3)$$

or:

$$\begin{aligned}\% \text{ Pores (MDV)} + \text{Voids} &= 100 - \% \text{ Displ. Vol. (MDV)} \\ &= \frac{\text{MDV} - \text{Displ. Vol.} \times 100}{\text{MDV}} \quad (4)\end{aligned}$$

and:

$$\% \text{ Displ. Vol. (B\&D)} = \frac{\text{Displ. Vol.}}{\text{B\&D Vol.}} \times 100 \quad (5)$$

or:

$$\begin{aligned}\% \text{ Pores (B\&D)} + \text{Voids} &= 100 - \% \text{ Displ. Vol. (B\&D)} \\ &= \frac{\text{B\&D Vol.} - \text{Displ. Vol.}}{\text{B\&D Vol.}} \times 100 \quad (6)\end{aligned}$$

A4.1.7. *Practical Application of Data:* It will undoubtedly be some time before data of this character can be related to the practical operational behavior of various samples of material in the field. A convenient means of following porosity characteristics on the basis of simple accurate measurements, however, is provided in the technique described, and a mass of routine measurements in the future should serve to establish its significance in testing the quality of granular media in field use.

Sec. A4.2—Short Method—Alternate No. 1

About 40 ml. of oven-dried exchanger shall be poured into 50 ml. water in a 100-ml. graduate. The material shall be agitated thoroughly. Sufficient time shall be allowed for the water to enter the pores, for the released air bubbles to escape and for the water to cool off to room temperature again (placing dried exchanger in water raises temperature). The volume of water displaced by the dried exchanger shall be assumed to represent the *absolute volume* of exchanger (exclusive of interstices and pores).

The adhering moisture from this wet exchanger shall then be removed by means of air-drying, being careful, however, to avoid excessive drying which would again remove some of the moisture from the pores. This exchanger with moisture-filled pores shall then be placed in 50 ml. water in a 100-ml. graduate. In this case the volume of water displaced equals *absolute volume of exchanger plus pore volume.*

To obtain the volume of pores, the *absolute volume* previously obtained shall be deducted from this *absolute volume plus pores:*

$$\% \text{ Porosity} = \frac{\text{Pore Vol.}}{\text{Abs. Vol.} + \text{Pores}} \times 100$$

Sec. A4.3—Short Method—"Wetdown" Density—Alternate No. 2

A4.3.1. *Procedure:* A 100-ml. graduate shall be weighed on a balance. 50 ml. water shall be added and about 50 ml. of material "as received" poured in slowly. The material shall then be stirred well, tamped and weighed. Volume of wet material in graduate and total volume of water plus material shall be noted.

A4.3.2. *Calculation of Wetdown Density:* Wetdown density shall be calculated as follows: Let a = weight of graduate, empty, and b = weight of graduate filled; then $(b - a - 50)$ = weight, in grams, of sample taken (W). Also, let V = volume occupied by sample under water; then W/V = specific gravity of sample in place, and $W/V \times 62.4$ = pounds of material "as received" to give 1 cu.ft. in place.

A4.3.3. *Oven-Dried Samples:* A similar determination shall also be made on oven-dried samples and the result recorded as the weight per cubic foot of the material on a 105°C. dry basis.

A4.3.4. *Swelling:* Materials that exhibit swelling tendencies shall be checked at intervals after the start of the soaking period and the volume shall be determined when swelling has ceased.

SUPPLEMENTARY NOTES

The italic headings identifying these notes refer to the section of the manual to which they relate and not necessarily to the statements contained in the notes.

Sec. 7.2—Air-Drying Procedure: The air-drying procedure outlined in Sec. 7.2 of the manual may also properly give attention to the following requirements: room temperature shall be maintained at 70°F. ± 10°F.; humidity shall be determined and noted, avoiding test under extreme atmospheric moisture conditions; drafts shall be eliminated.

Sec. 15.11.2—Capacity as Received: The rinse rate of flow or length of rinse (in time) shall be as required for the type of exchanger used or as called for in general specifications for particular installations. These approximate: for greensand, 20–25 min.; for high-capacity greensand, 35–40 min.; for carbonaceous and resinous exchangers, 40–45 min.; and for synthetic exchangers, 55–65 min.

Sec. 17.3.2—Silica: The largest and most troublesome error in the silica determination is the one due to the solubility of the SiO_2 in the HCl. The amount of freshly precipitated SiO_2 that dissolves in HCl depends on the following conditions: (1) the amount of acid present; (2) the strength of the acid; (3) the temperature; and (4) the length of time the silica is in contact with the acid. There may be other conditions governing the solubility of SiO_2 in HCl, but these seem to be the principal ones. By far the most important is the amount of acid used. Most chemists use acid of about the same strength to treat the dehydrated silica. The assays are brought to a boil, insuring the same temperature, and are boiled for a fairly uniform length of time. Few, however, consider the importance of using a definite amount of acid. When a small amount of SiO_2 is present, the amount dissolved is proportional to the quantity of acid solution present and not to the amount of SiO_2 in the sample.

Sec. 17.3.3—Alumina: (*a*) The precipitation of aluminum hydroxide is complete between pH 7.0 and 7.5. Indicators showing an alkaline reaction at 7.0–7.5 should be used. With a pH exceeding 10, the hydroxide is appreciably soluble, aluminum later appearing with the calcium and magnesium precipitates.

(*b*) Since the carbonate is precipitated by addition of lime in the distilling flask, the freshly distilled ammonia is best kept in a ceresine or paraffin bottle. It will then remain free from silica, which it invariably contains when confined in glass bottles.

(*c*) It is advisable to filter as soon as possible after making the precipitation of $Al(OH)_3$. Long heating of the mixture containing the aluminum precipitate is objectionable because: (1) The solution is apt to become acid, due to the decomposition of ammonium salts and the volatilization of ammonia. (2) The precipitate will become slimy and will be difficult to wash and filter; it is preferable to redissolve and again precipitate if this condition occurs. (3) The CO_2 of the air is apt to be absorbed by the solution, causing the precipitation of calcium carbonate, etc., if the solution is exposed for any length of time. (4) Silica from the beaker will contaminate the precipitate.

(*d*) Washing the precipitate with ammonium nitrate prevents the aluminum from passing through the filter and keeps it from packing. It favors the formation of the insoluble hydrogel form of the hydrate while preventing the formation of the soluble hydrosol.

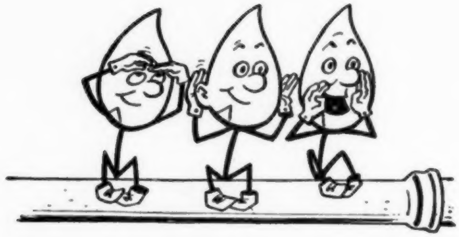
Sec. A3.1.1—Solutions: If cp. sodium chloride is not used for regeneration of samples, an analysis of the salt used shall be made by accepted methods and the analysis recorded; or an analysis of the brine shall be made and recorded.

ONE LITTLE GIRL

A little girl was dead. That was the news—just one little girl. Three days ago only a few people knew the name of this little girl. Yesterday there was no one in this country and few in other civilized countries who had not heard of 3-year-old Kathy Fiscus of San Marino, Calif. Millions upon millions followed this heartbreaking story as they did no other news of the day. This morning those millions share the grief of Kathy's parents.

Yet even Kathy's father and mother must have felt that something like a miracle of human compassion had taken place. Their little daughter had suddenly become a symbol of something precious in all our lives. The world is overladen with great problems. Two great wars and many smaller ones have cost the lives of multitudes, including little girls just as dear to their parents as Kathy was. But we still know, even if the mad theorists at the other side of the world do not, that one life—one tiny life—is beyond price. Kathy came close to our hearts and made us one. A splendor of unselfish emotion lit her path as she went from this earth.

This editorial appeared in the New York Times on April 11, 1949, after rescue workers had reached little Kathy Fiscus and her fate had been learned. It offers better evidence than the language at our command to indicate how the whole civilized world stood in sympathetic companionship with our fellow member, David Fiscus, and his wife.



Percolation and Runoff

Glamour has never been one of the strong points of the water works industry, but, with the unsolicited aid of some of Hollywood's shiniest screen stars, it may yet offer us salvation from the pressing problems of low rates and high consumption. In any event the recent report that filmland's favorites have quit the tap and hit the bottle for their drinking water carries with it the promise that every loyal fan will ban the faucet faithfully and forthwith. And therein hangs our hope.

The obsolescence of Screenville's taps came in a virtual inundation of bottled waters, fortified with vitamins, minerals, chemicals and a host of other helps to health and happiness. And, by now, an enterprising actress, one Theodora Lynch, has dropped a noose around a large part of the market with a "real" glamour water all but guaranteed to glorify the puss of every purchaser. Bottled in Hereford, Tex., "the town without a toothache," this latter supply, according to "medical experts," is loaded with fluorine, calcium, potassium and phosphate, which cannot fail to give every star the pretty smile and good teeth characteristic of the 7,000 humans and unnumbered horses of Hereford. Delivering a $1.25 five-gallon jug twice a month direct from the property she recently bought in the Texas town, entrepreneuse Lynch has virtually assured the permanence of her project by selling her elixir to such style-setters as Joan Crawford, Dick Haymes, Bonita Granville, Joan Davis, Lou Costello (sans, however, Abbott) and Kirk Douglas.

With such auspicious acceptance at the fount of fad, we cannot doubt that the clamor for glamour will soon resound from coast to coast. Thus it behooves us at once to take an inventory of the consequences:

First, of course, we can count on an immediate reduction of consumption. No longer will our thirsty public waste a gallon or two to get a glassful from our taps. And with summer coming that should provide a significant amount of relief.

Second, although the rates for the tap supplies will remain essentially unaffected, major relief should be provided by the opportunity offered wa-

(Continued on page 4)

(*Continued from page 2*)

ter works to bottle a portion of their supplies for sale at glamour prices. It is almost certain that the Hereford fan clubs, for instance, will want to import their water from Hollywood; that rabid residents of Podunk will want New York City water; and so on *ad pecuniam*.

Third, if Miss Lynch is successful in her further exploitations, which involve incorporating her Hereford supply in toothpaste, soft drinks and cold cream, water works men will have still another remunerative field in which to market their own distinctive products.

All in all, the possibilities are about as stupendous and magniloquent as anything we've seen come out of Hollywood for a long time. And if cynics insist on pointing out that our earlier excitement about milk and champagne baths came to naught, we can pooh-pooh their pessimism with aplomb. After all where could fans get milk or champagne for two bits a gallon, and how could anyone check up on their use of it? No, this is different, and we're already thinking in terms of glamour by the gallon.

Never necromantic, Willing Water has suddenly become neck-romantic in his newest application, decorating the hand-painted cravats of various and sundry Southwest Section members who are following the fashion of Jimmy Highfill of Springdale, Ark. It was Jimmy who took due note of the functional figures festooning the neckwear of his local business associates and applied the talents of the artist to hanging a faithful facsimile of Willie around his neck. The stir he caused at the last Oklahoma Short School sent other members shopping for telltale ties of their own. Thus Mrs. Billie Maestri of 709 W .Emma Ave., Springdale, is by way of becoming official Willie worker of the Section. Having begun her illustrating for her own amusement, she is by now doing a land-office business, reproducing as many as five Willing Water wonders per tie at a standard price of $7.50.

Meanwhile, up at Canadian Section headquarters, the selfsame Willie has teamed up with Secretary Berry to tell and sell the story of A.W.W.A. membership benefits to water workers throughout the Dominion in a broadside of lively logic.

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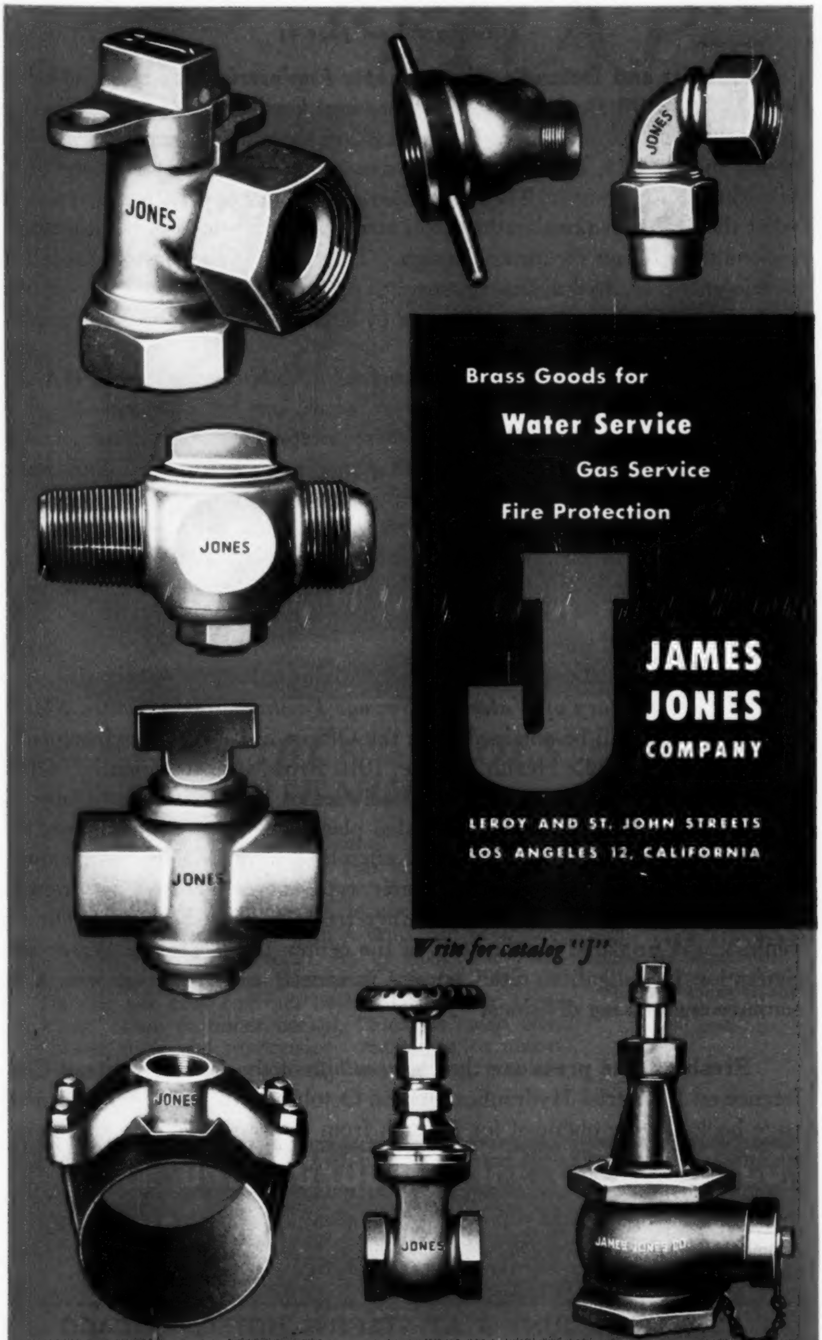
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(*Continued from page 4*)

Babbitt and Doland's *Water Supply Engineering* has been published by McGraw-Hill Book Co. in its new, fourth edition ($6.50). The ten years that have elapsed since the last edition have seen many new developments in the field, and the authors have revised their text thoroughly to take them into account. They have also recast their approach to emphasize what they call functional rather than structural procedure—practical applications rather than theoretical design. The result is that much theoretical development of hydraulics, financing, pumping equipment and similar topics has been omitted and supplanted by applications of the basic principles.

Publication of the *American Standard Plumbing Code* by APHA and ASME under ASA standardization procedure has been announced. The code gives mimimum safety and health requirements for the design, installation, inspection and performance of plumbing systems, including water supply, distribution, drainage and venting systems. Extensive researches were conducted and various codes, laws and ordinances were reviewed in the development of the document. Copies are available at $2.50 each from the American Society of Mechanical Engineers, 29 W. 39th St., New York 18.

More than 900 copies have been distributed since publication last year of the *Inventory of Water and Sewage Facilities in the United States,* but copies may still be obtained from the Officer in Charge, Environmental Health Center, Public Health Service, 1016 Broadway, Cincinnati 2, Ohio. A massive document which lists the facilities of all incorporated places of over 100 population and unincorporated places of over 500 population, the inventory serves also as a source of current information on basic sanitation needs. Details on sources of water, type of treatment plant, sewerage facilities and method or extent of sewage treatment are included. The inventory was prepared by the staff of the center (formerly the Water and Sanitation Investigations Station) at Cincinnati, in cooperation with state sanitary engineering divisions.

Fresh off the press are the *Proceedings* of the fourth National Conference on Industrial Hydraulics, held in October 1948. Copies of the 154-page book may be obtained for $3 each from S. F. Musselman, conference secretary, at Technology Center, Chicago 16. The twelve papers included discuss such subjects as flanged joints, gaskets, packings and seals, hydraulic surges, and various farm and industrial applications.

(*Continued on page 8*)

(*Continued from page 6*)

The cutieless calendar recently dispatched by Art Clark for the WSWMA ought to be adequate reminder that the Chicago Conference is virtually here. But, lest that be insufficient invitation: cast a glance at the technical program recently sent to all members; remember that Bill Orchard and Joe Wafer have another entertainment treat in store for you; be advised that there will be 131 boothsful of new equipment on exhibit; oil up your reminiscences and look forward to a four-booth display of antiques including at least 50 pieces of equipment and a separate group of photographs; and, finally, think about the opportunity offered for meeting upwards of 2,000 water works men and their wives. We'll see you at the Stevens come May 29!

The drought bout continues on a global front, uncovering weirder wonders in every round:

At Rolle, Switzerland, for instance, the level of Lake Geneva recently receded to so low a point that a marked stone on the lake bed made its first appearance since the dry spell of 1921, bringing to light the enigmatic inscription: "When you see me, cry." Old Rollers indicated that the words refer to the rigors endured during bygone droughts, but were uncertain whether the tears consequent had ever been adequate in volume to alleviate the situation.

At Monroe, Ore., on the other hand, it was the fact that the water shortage of last winter was self-inflicted which invited more jeers than tears. For there it was that residents, fretful that their plumbing would freeze, left their faucets running so loud and long that they completely drained the reservoir.

At Niteroi, Brazil, shortly thereafter, it was drought that discovered a candid milkman, who completely disarmed customers complaining of tadpoles in their milk by explaining that the water shortage had forced him to discontinue his normal practice of watering the milk at a fire hydrant and sent him to the nearest creek.

At Essex County, N.J., meanwhile, where the drought was further advanced, it was full-grown frogs which startled the populace, not in their milk, but riding the raindrops of the storm which broke the dry spell. And, though meteorologists contended that the precipitants were toads, not frogs, and that they had emerged from the ground rather than the sky, eyewitnesses who saw them bouncing on cartops and splattering the road are inclined to trust their sight more than science.

Finally, *at Bogota, Colombia,* it was the puissance of prayer which discommoded the citizenry. There, after ten days of sec supplication for rain, Bogotans begot themselves an overdose of blessings and had to call out the army and the Red Cross to assist in fighting the flood that followed.

(*Continued on page 10*)

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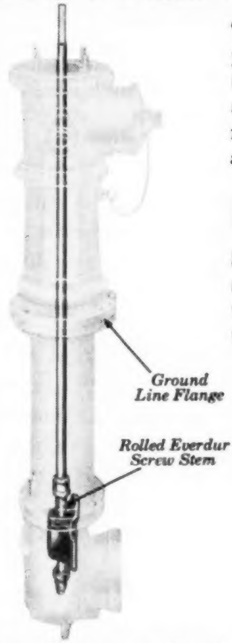
Not so much "pigeons on the grass, alas" as pigeons on the roof, aloof, are what's worrying persnickety public officials throughout the U.S. and driving them to new depths of craft and cunning in devising unscrupulously unsubtle "No Parking" signs for their fine feathered friends—unwanted unhousebroken. Up in Albany, N.Y., for instance, some practical joker has achieved respectability by contributing from his store of lore an electronic hotfoot more or less guaranteed to protect the august edifices and edifiers in the Empire State Capital against the uninhibitions of the winged worriers. How successful is this shock treatment, effected by intermittent electrical impulses through wires strung on the visitors' vantage points, we have not yet observed, but we understand it keeps them hopping, stopping dropping.

California pigeon parking, on the other hand, has been found more persistent. Neither the trapping system devised at Los Angeles nor the stuffed-owl scarepigeons erected by San Francisco were in the least effective in "reducing the nuisance." Unsurprisingly undismayed by California's experience, Florida's Jacksonville city council recently voted a $4,500 appropriation to "have the pigeons trapped, executed and fed to city prisoners." Although it is not certain whether this action is aimed pri-

(*Continued on page 12*)

SERVICE . . . *with a monkey wrench!*



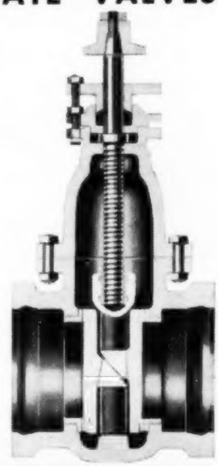
To inspect or service a Ludlow Slide Gate Hydrant you'll need a wrench — that's all. Just take off the top of the hydrant and lift out the stem, *without unscrewing anything below ground.* The entire mechanism, including the gate, bronze wedge nut and drip assembly is attached to the stem.

LUDLOW FIRE HYDRANTS

Shown here is the distinctive Ludlow List No. 90, now serving in thousands of cities and towns. It employs the famous Ludlow Slide Gate principle, and (in addition to easy servicing) offers the following advantages:

- *Quick Water* with least possible shock and pressure loss. Proper shut-off without water hammer.
- *Proper Drainage,* automatically, at lowest point when closed.
- *No Flooding.* Wedge-locked when closed. Accidental breaking will not cause flood. Hydrant head breaks at ground line — is easily replaced without excavation.

LUDLOW AWWA DOUBLE DISC GATE VALVES



The parallel seated, double wedge type slide gate valve, developed and perfected by Ludlow, provides a number of essential benefits.

- *Smooth, Positive Operation.* Gates positioned directly opposite ports before wedging, and entirely unwedged before being raised.
- *Positive Closure.* Even after years of service in the open position; flexible-action gates self-adjusting to seats.
- *Simplicity!* Only 2 parts in the wedging mechanism! These are extra heavy with ample reserve strength and wear resistance for years of constant service.

Made in sizes from 2" to 72", N.R.S. and O.S.&Y. with all types of connections.

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TRADE LUDLOW MARK

The LUDLOW VALVE SINCE 1866

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(Continued from page 10)

marily at the pigeons or the prisoners, it must in any case be deemed "cruel and unusual punishment" of one or the other. But it is in staid old Boston, home of the black bowler hat, that the most insidious inspiration has been at play. There we find direct descendants of our puritan progenitors feeding the birds a gin-spiked mash in an endeavor to dizzy them off their perches or at least to corrupt their coordination.

What terrors of turpitude will next be revealed in this bird-brain battle we dare not imagine, but we have reason to believe that the still secret system employed at Washington, D.C., will turn out to be the goriest as well as the most effective. Latest reports, at least, indicate that even the dove of peace hasn't yet risked a landing there.

Bird-burdened are New Yorkers, too, with a triple-threat nest of pigeons, sparrows and seagulls in their hair. And although they have more or less consented to abide the excesses which attend both pouting and chirping, they have felt the necessity of drawing the line at the indiscretions of the winged wave-riders who dot the surface of the city's billion-gallon capacity Central Park Reservoir, providing, as it does, the drinking water supply of approximately a million metropolites. Thus, each morning, Ciro F. Russo, operator of the reservoir's chlorination plant, lets loose an ear-piercing blast on his trusty shotgun. Only trouble is gulls ain't gullible, so, though they usually oblige with a five- or ten-minute soar, they don't even bother to await Russo's departure before returning to their roost.

Since aiming his blunderbuss would be illegal and since aiming it accurately would undoubtedly add more pollution than it subtracted, Russo has resigned himself to the task of overcoming rather than preventing the contaminative contributions of his web-footed wards. Meanwhile, water department officials, who won an easy victory over various and sundry human polluters merely by erecting a fence, are by now becoming fed up with getting the bird and may well consider the more drastic defenses of roofing or relocation. Whatever the decision, contiguous consumers won't be unhappy to see the gull gall go.

Less pertinacious than a gull was one H. A. May of Monroe, La., who recently descended upon the Millburn, N.J., reservoir of the Commonwealth Water Co. in his two-seater seaplane. Forced down by weather conditions, May found he could not take off again because of a leak in his pontoon, so left his plane there for the night. It really didn't require the urging of Roswell Roper Jr., in charge of the water reserve, and the policemen he had summoned to speed May's departure, for, obviously, he was a migratory bird, headed for Quincy, Mass. Besides, the Commonwealth water isn't as soft as the New York supply.

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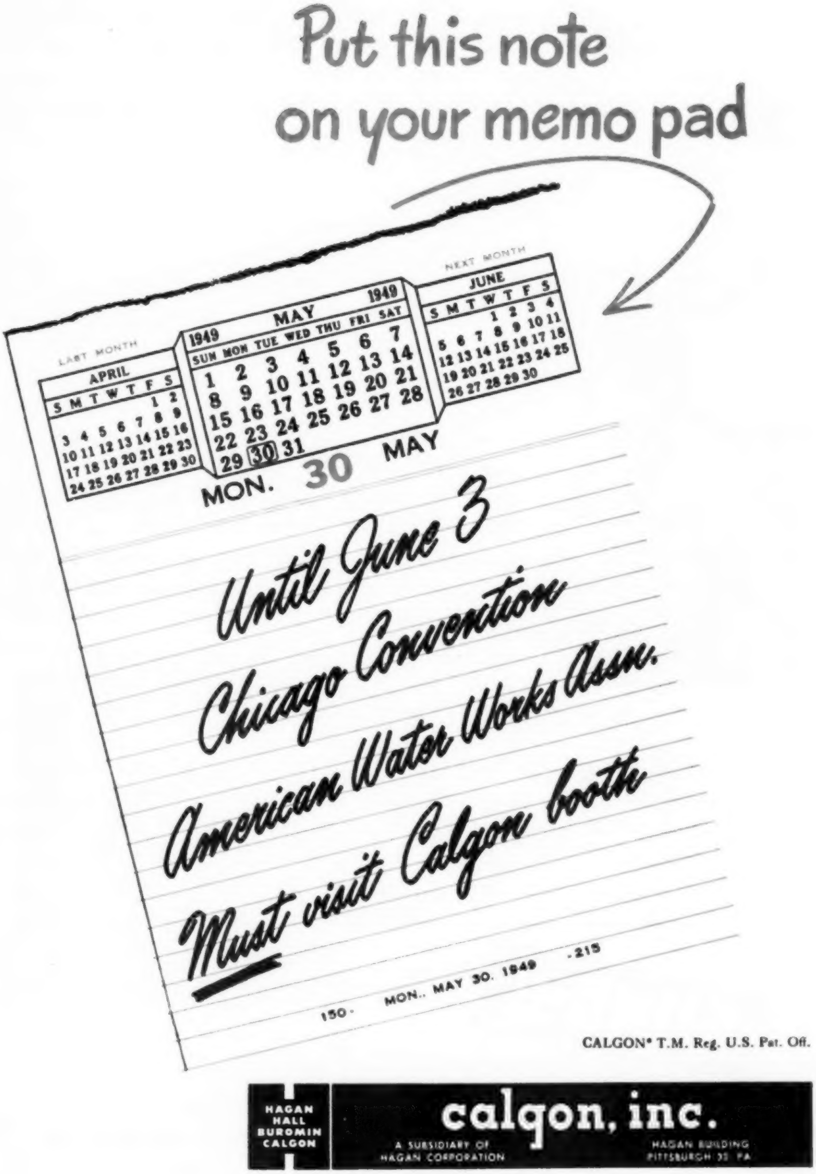
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(Continued from page 12)

Sol Pincus, New York consultant engineer, has gone to Geneva, Switzerland, where he will set up a section on environmental sanitation for the World Health Organization. Environmental sanitation was made one of the six top priority programs of the first World Health Assembly when it met in Geneva last summer. Past activities of Pincus include assignments with the U.S. Public Health Service and with the New York City Dept. of Health, in which he served as Deputy Commissioner from 1935 to 1947, directing sanitary engineering and food control activities.

Wild Bill's the monicker, and if you don't think he's the rootinest-tootinest water works man this side of the border, take a squint at the "pitcher." That bronco he's astride is just one of the many he busted so hard he like to killed 'em. And you better not say nuthin about that bow tie, cuz Bill ain't no slouch with his six-shooter neither, even if he keeps it under cover these days.

Seriously, though, we've been glad to note that our friend Bill Birch is flourishing under the strong, if intermittent, influence of the Arizona sun and he'll be back from his frontier vacation in time for the Chicago Conference. Thus, we'll leave to him the telling of such tales as the jaunt to Superstition Mountain and the steak dinner in a cactus and sky dining room.

Robert D. Wright of the Lynchburg, Va., water department, has been advanced to the post of superintendent. Previously his title had been acting superintendent.

(Continued on page 18)

(Continued from page 14)

Further information is now available on the Cedar Rapids, Iowa, water works superintendent's position announced in the February JOURNAL (P & R, p. 18). Requirements are an engineering degree plus ten years' experience or a B.S. degree plus twelve years' experience. Age range 30 to 50 years; starting salary, $6,000 to $7,500. Apply Civil Service Com., City Hall, Cedar Rapids for applications and information. Deadline, May 20, 1949.

P. S. Wilson has added to his activities the representation in the New York area of the Atlas Mineral Products Co.

William T. Ingram, formerly engineering field associate for the American Public Health Assn., has been appointed associate professor of public health engineering at New York Univ. College of Engineering. His recent activities with A.P.H.A. included extensive studies of public health engineering administration and sanitary training facilities throughout the United States. It is expected that his studies, added to his eighteen years of engineering experience, will further the development of professional training for sanitary and public health engineers.

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HYDRO-TITE

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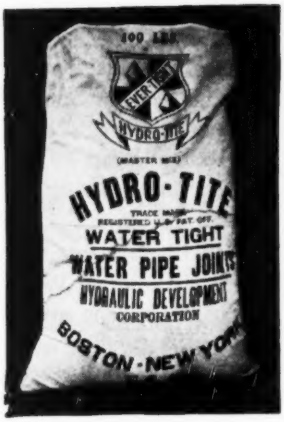

Hydro-tite, the self-sealing, self-caulking, jointing compound can be supplied promptly in any quantity at any time from our warehouse stocks strategically located throughout the United States and Canada. Over thirty years of use has proved that pipe joints made with Hydro-tite, stay tight. Send for data book and sample.

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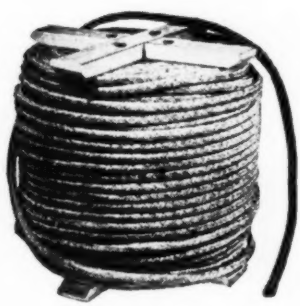

The sanitary, bacteria-repellent paper packing that is used like braided jute. Seventy pounds of Fibrex takes the place of one hundred pounds of braided jute, with proportionate savings in cost. Send for sample.

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Main Sales Office: 50 Church St., New York, N. Y.

Works: West Medford Station, Boston, Mass.

(Continued from page 18)

Short courses for water and sewage works personnel to be given shortly include one to be held from June 29 to July 1 at Louisiana State Univ., Baton Rouge—the twelfth in the annual series sponsored by the university's General Extension Div. in cooperation with the state board of health and Louisiana Conference on Water Supply and Sewerage. Another school, on sewage works only, will be held at State College, Pa., June 13–17, and will feature elementary, intermediate and advanced courses. Information is available from H. G. Pyle, Extension Service, State College, Pa.

New Jersey appointments to the State Water Policy and Supply Council, recently announced by Gov. Driscoll and confirmed by the State Senate, include Roswell M. Roper, engineer and general manager of the East Orange Board of Water Comrs., and Max Grossman, assistant superintendent and engineer of the Atlantic City water department.

Edwin J. Lame, vice-chairman of the board of R. D. Wood Co., died at his home in Wynnewood, Pa., on March 26th, after a brief illness. He had entered the employ of the company in 1887 as an office boy and rose to the post of vice-president, which he held from 1918 until 1947. He resigned that office in the latter year to become vice-chairman of the board.

Holiday Spring, a brook that babbles only when it is assured of an appreciative audience, is one of our favorite phenomena. Located just south of Syracuse, N.Y., in the state-owned recreation area around Green Lake, this manifestation of geologic exhibitionism owes its appellation to the mystifying fact that it flows only on Sundays and holidays. Impossible to chart are the fabulous flights of fancy enjoyed by imaginative observers. And more than rife, their speculation has an unmistakable aura of romance —an aura we've always endeavored to cultivate.

How then can we accept as more than idle iconoclastic inference the disillusioning data offered by so mundane an eyewitness as Arthur Clark, who attempts to explode the entire enigma with the explanation that a silk mill half a mile away, which obtains its water supply from deep wells, draws down the ground water level on working days to an extent which prevents the spring from flowing? Phooey! say we. Who ever heard of a mill made of silk?

James R. Brown has resigned as Vice-President in charge of sales promotion for National Water Main Cleaning Co. to accept a position with the Trojan Tool Equipment Co., Chicago, Ill. The company is the exclusive distributor for Flexible Sewer-Rod Equipment Co. in the Midwest.

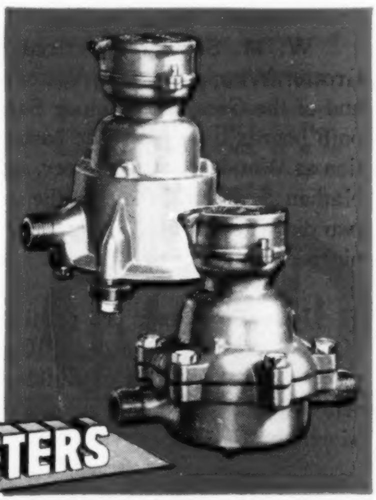
(Continued on page 22)

"Badger Meters are the *best*...when we buy more they will be Badgers"

A waterworks superintendent wrote this, and went on to say: "Our average dead meters for a year was only 7 per month . . . about as low an average as I know of. Your city cannot go wrong buying Badgers".

Millions of satisfied users of Badger Meters in over 5000 communities prove that "It Pays to BUY BADGER" . . . unmatched in precision-construction, durable materials, and sustained accuracy, at lowest operating cost.

You will find a Badger Meter size and type for every waterworks service. Shown here are Model SC-SOT (for warm climates), and Model A-SOT (for cold climates) . . . sizes 5/8" to 1 1/4" . . . other models in sizes up to 12". Write for complete information and prices.



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ACCURACY · LOW-COST MAINTENANCE · DURABILITY · SENSITIVENESS

(*Continued from page 20*)

The Great Gildersleeve being awarded an A.W.W.A. Membership Certificate (left) as Los Angeles commissioners R. A. Heffner, W. B. Himrod and Duncan Shaw look on. At right, Morris pours Gildersleeve a glass of that magic stuff.

Radio's water commissioner, the Great Gildersleeve, received an A.W.W.A. Membership Certificate during ceremonies broadcast over the NBC network on Wednesday evening, March 23rd. After a half-hour of having "Mr. Morris, of the Los Angeles water department" held up to him as a model executive, the suffering water commissioner of mythical Summerfield discovered that Samuel B. Morris was more than a paragon for the delinquent to emulate. In his capacity of Past-President of the A.W.W.A., Morris bestowed the certificate on Gildersleeve (Hal Peary) as an expression of the membership's appreciation of his work.

W. M. Scott has retired as chairman of commissioners of the Greater Winnipeg, Man., Water District—a post he has held since 1920—and of the Greater Winnipeg Sanitary District. He continues to serve on both boards on a part-time basis. W. D. Hurst, while retaining his position as Winnipeg city engineer, succeeds to the chairmanship of both boards. Nathan S. Bubbis assumes the new post of acting general manager of the two districts, having been granted a year's leave of absence from the Winnipeg engineering department.

John R. Purser Jr., president of Purser & London, of Charlotte, N.C., was recently awarded a 10 years' service pin at a dinner honoring employees and associates of Builders Iron Foundry. Purser & Long represents the affiliated Providence companies—Builders-Providence, Omega Machine and Proportioneers—in North and South Carolina.

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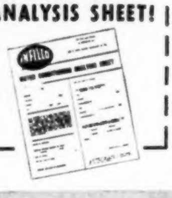

PROFESSIONAL SERVICES

Membership Changes

NEW MEMBERS

Applications received March 1 to 31, 1949

Adams, E. B., Mgr., Water, Gas & Light Dept., Albany, Ga. (Jan. '49)

Ambuhl, Marvyn R., Div. Sales Engr., Armco Drainage & Metal Products, Inc., 2321 S.E. Gladstone St., Portland, Ore. (Jan. '49)

Anderson, B. Conn, *see* Auburn Water Works Board

Appleyard, V. A., Asst. Mgr., City Water Com., 126 E. 10th St., Chattanooga, Tenn. (Jan. '49)

Archer, Lawrence J., Sr. Civ. Engr., Water Dept., 425 Mason St., San Francisco 2, Calif. (Jan. '49)

Auburn Water Works Board, B. Conn Anderson, Secy., Box 511, Auburn, Ala. (Corp. M. Jan. '49)

Barlow, Emil T., Civ. Eng. Assoc., Dept. of Water & Power, 510 E. 2nd St., Los Angeles 12, Calif. (Jan. '49)

Belleville, Laurier, Supervising Engr., National Health & Welfare, 379 Common St., Montreal, Que. (Jan. '49)

Bouwman, J., Sales Repr., Johns-Manville Sales Corp., 510 American Bldg., Cincinnati 2, Ohio (Jan. '49)

Brock, C. M., Water Works Supt., Munic. Water Utility, Cleveland, Miss. (Jan. '49)

Brown, L. L., Supt., Water & Sewers, Harrison, Ark. (Jan. '49)

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(*Continued from page 28*)

Burba, Foster S., Instructor, Eng. Extension, Oklahoma A & M, Stillwater, Okla. (Jan. '49)

Burgi, Herman, Jr., Chief Engr. & Asst. Mgr., Water Dist., 16 Casco St., Portland 2, Me. (Jan. '49)

Caracas, Acueductos de, J. M. Soteldo R., Director, Instituto Nacional de Obras Sanitarias, Caracas, Venezuela (Corp. M. Jan. '49)

Carter, Jay B., San. Eng. Asst., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Jan. '49)

Caton, M. O., Dist. San. Engr., State Board of Health, Box 363, Ayden, N.C. (Apr. '49)

Choca, Maria D., Prof. of Mathematics, Instituto de la Vibora, Maloja 607, Havana, Cuba (Jan. '49)

Churchill, M. A., Public Health Engr., Tennessee Valley Authority, 101 Arnstein Bldg., Knoxville, Tenn. (Jan. '49)

Cook, L. F., Supt., City Bldg., Front & Broad Sts., Cuyahoga Falls, Ohio (Jan. '49)

Cordes, Erwin H., Civ. Engr., St. Louis County Water Co., 6600 Delmar Blvd., University City 5, Mo. (Apr. '49)

Cotton, Edwin R., *see* Potomac River Basin Interstate Com.

Cunningham, M. B., *see* Trinidad Water & Sewer Dept.

Daly, Maurice R., *see* Fall River Water Dept.

David, John M., Dist. Mgr., Layne-Atlantic Co., Box 356, Albany, Ga. (Jan. '49)

Dean, Maurice F., Asst. Engr., Public Service Com., 601 Barrington St., Halifax, N.S. (Jan. '49)

Delhi Public Utilities Com., (Mrs.) B. R. Hill, Secy., Delhi, Ont. (Corp. M. Jan. '49)

DePhillips, A., Repr., Diamond Alkali Co., 431 S. Central Ave., Baltimore 2, Md. (Jan. '49)

Donnelly, Henry J., Supt., Water Dept., Bellingham, Wash. (Apr. '49)

Elbring, William W., Civ. Engr., St. Louis County Water Co., 6600 Delmar Blvd., University City 5, Mo. (Apr. '49)

Ernst, George C., Prof. & Acting Chairman, Dept. of Civ. Eng., 208 Mechanic Arts Bldg., Lincoln, Neb. (Jan. '49)

Eschman, Leo E., Asst. Chemist, Mahoning Valley San. Dist., 646 Paige Ave., N.E., Warren, Ohio (Jan. '49)

Fall River Water Dept., Maurice R. Daly, Supt., 1620 Bedford St., Fall River, Mass. (Corp. M. Jan. '49)

Feltham, John C., Civ. Engr., Infilco, Inc., Box 233, Edgefield, S.C. (Jan. '49)

Foster, Charles B., Jr., Asst. Supt. & Engr., Dept. of Water & Sewerage, City Hall, Shreveport, La. (Jan. '49)

Fox, J. Elmer, Supt., Dept. of Public Works, Borough Hall, Ramsey, N.J. (Jan. '49)

French, Clarence B., Civ. Engr., Water Div., City Hall, Waltham 54, Mass. (Jan. '49)

Fulbright, C. O., *see* Fulbright Labs., Inc.

Fulbright Labs., Inc., C. O. Fulbright, Pres., 213 E. Tremont Ave., Charlotte, N.C. (Corp. M. Jan. '49)

Garner, Guy A., Water Service Supervisor, Water Works, 68 Mitchell St., S.W., Atlanta, Ga. (Jan. '49)

Gerlitz, F. E., Jr., Sales Mgr., Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia 42, Pa. (Jan. '49)

Gildersleeve, Throckmorton P., Water Comr. of Summerfield, 612 Taft Bldg., 1680 N. Vine St., Hollywood 28, Calif. (Jan. '49)

Goble, Harry W., Water Clerk, Township of Parsippany-Troy Hills, Cobbs Corner, Parsippany, R.D. No. 1, Boonton, N.J. (Jan. '49)

Godbe, Hampton C., Exec. Secy., Metropolitan Water Dist., 2152 Parkway Ave., Salt Lake City, Utah (Jan. '49)

Goellner, Fred J., Valuation Engr., Public Service Com., 233 Broadway, New York 7, N.Y. (Jan. '49)

Gonzalez, Carlos E., Graduate Student, Univ. of Illinois, 1115 W. Oregon, Urbana, Ill. (Jr. M. Jan. '49)

Graham, Harold H., Civ. Eng. Assoc., Dept. of Water & Power, 207 S. Broadway, Los Angeles 12, Calif. (Jan. '49)

Granados, Juan A., San. Engr., Com. de Malaria de Cuba, Apdo. 157, Havana, Cuba (Jan. '49)

Hallam, George O., Chemist, Water Dept., Village of LaGrange, 741 S. Bodin St., Hinsdale, Ill. (Jan. '49)

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Hamlin, Guy R., City Engr. & Airport Mgr., 435 Carter Blvd., Seymour, Ind. (Jan. '49)

Hausser, Charles A., Borough Engr., Kings Rd., Madison, N.J. (Jan. '49)

Hill, B. R. (Mrs.), *see* Delhi Public Utilities Com.

Hjaltalin, Sig, Pres. of Council, 3912 Broad St., Bellingham, Wash. (Apr. '49)

Holton, City of, Virgil C. Knowles, City Mgr., City Hall, Holton, Kan. (Corp. M. Jan. '49)

Huot, Marcel, Town Engr., 14 rue de l'Eglise, Ville St. Laurent, Que. (Jan. '49)

Ithaca Water & Sewer Dept., Thomas G. Miller Jr., Supt., City Hall, Ithaca, N.Y. (Mun. Sv. Sub. Jan. '49)

Jensen, Marinus, Water Supt., Water Dept., Albert Lea, Minn. (Jan. '49)

Johnson, W. H., Dist. Supt., Water Meter Div., Rockwell Mfg. Co., 50 Church St., New York 7, N.Y. (Jan. '49)

Kenney, Don, Foreman, Water Dept., 305 S. Oak St., McPherson, Kan. (Jan. '49)

King, J. S., Mgr., Chicago Branch, Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago 5, Ill. (Jan. '49)

Knowles, Virgil C., *see* Holton, City of

Ling, Joseph T. T., Graduate Student, Univ. of Minnesota, 315 University Ave., Minneapolis, Minn. (Jr. M. Jan. '49)

Mahapatra, Mrutyunjaya, Public Works Engr., San. Eng. Dept., Johns Hopkins Univ., Baltimore 18, Md. (Jan. '49)

Martin, F. V., Sales Repr., Mueller Co., 5911 S.E. Firwood St., Portland 2, Ore. (Jan. '49)

Marvick, Byron G., Partner-Mgr., Culligan Soft Water Service, 519 E. Broadway, Glendale 5, Calif. (Jan. '49)

McEwen, J. E., Mgr., Munic. Water Dept., City Hall, Warren, Ark. (Jan. '49)

McKay, Charles R., Sr. Operator, Water Plant, Water & Sewer Dept., Brownsville, Tenn. (Jan. '49)

McKinney, Ross Erwin, Student, Massachusetts Inst. of Technology, 607A Graduate House, Cambridge 39, Mass. (Jr. M. Jan. '49)

Miller, Thomas G., Jr., *see* Ithaca Water & Sewer Dept.

Mills, Donald, Cons. Engr., Box 534, Selma, Ark. (Jan. '49)

Nelson, Louis E., Utilities Supt., Munic. Light & Water, Windom, Minn. (Jan. '49)

Nelson, Walter J., Johns-Manville Sales Corp., Celite Div., 22 E. 40th St., New York 16, N.Y. (Apr. '49)

Olsen, Russ, Sales Engr., Badger Meter Mfg. Co., Box 1271, Nashville 2, Tenn. (Jan. '49)

Olson, H. M., Cons. Maintenance Engr., Morton Salt Co., 120 LaSalle St., Chicago 3, Ill. (Jan. '49)

Oswalt, W. H., City Mgr., Municipal Bldg., Jacksonville, Tex. (Jan. '49)

Parajon, Luis, Student, Univ. of Havana, Ave. Almendares 13, Alturas de Almendares, Havana, Cuba (Jan. '49)

Passmore, John, Mgr., Water Works Dept., Hensall, Ont. (Jan. '49)

Perkins, Frank P., Dist. Mgr., The Deming Co., 5012 N. 23rd Ave., Omaha, Neb. (Jan. '49)

Poston, J. C., Supt., Public Works, 50 Coteau St., W., Moose Jaw, Sask. (Jan. '49)

Potomac River Basin Interstate Com., Edwin R. Cotton, Director, 202 Transportation Bldg., Washington 6, D.C. (Corp. M. Jan. '49)

Randall, Frank G., City Engr. & Supt. of Water, Wadsworth, Ohio (Jan. '49)

Riley, Edward W., Engr., Coos Bay-North Bend Water Board, 264 S. Broadway, Coos Bay, Ore. (Jan. '49)

Robbins, John A., Supt., Dept. of Water Works, 55 N. 1st St., Scottsburg, Ind. (Jan. '49)

Rukavina, Matt K., Town Engr., Kapuskasing, Ont. (Jan. '49)

Salt Lake City Metropolitan Water Dist., Hampton C. Godbe, Exec. Secy., 1025 Kearns Bldg., Salt Lake City, Utah (Corp. M. Jan. '49)

Scholtz, Ted, City Engr., 210 Lottie St., Bellingham, Wash. (Apr. '49)

Schutt, Harold S., Pres., Indianapolis Water Co., 430 Continental American Bldg., Wilmington 33, Del. (Apr. '49)

Seffell, A. F., Water Supt., Yukon, Okla. (Jan. '49)

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Shiner, Stephen, Mng. Director, Aqualux Ltd., 81 Headingley Rd., Birmingham 21, England (Jan. '49)

Shuck, Earl, Plant Supt., Light, Water & Power Dept., Fairbury, Neb. (Jan. '49)

Smith, Charles T., Gen. Mgr., Munic. Utilities, Box 780, Owensboro, Ky. (Jan. '49)

Soteldo R., J. M., Director, Acueductos de Caracas, Instituto Nacional de Obras Sanitarias, Caracas, Venezuela (Jan. '49)

Stone, Angelo, Asst. Plant Supt., Munic. Utilities, Box 780, Owensboro, Ky. (Jan. '49)

Thuell, W. R., Mgr., Public Utility Com., Seaforth, Ont. (Jan. '49)

Trinidad Water & Sewer Dept., M. B. Cunningham, Supt., City Hall, Trinidad, Colo. (Corp. M. Jan. '49)

Vann, J. Thompson, Research Engr., American Cast Iron Pipe Co., Birmingham 2, Ala. (Jan. '49)

Van Treek, Joseph, Water Supt., Munic. Water Dept., Nutley, N.J. (Jan. '49)

Walker, Melvin T., Supt., Sylvan Spring Water Co., Verona Beach, N.Y. (Jan. '49)

Wardrop, W. L., Engr., Water Works & Sewerage, Ross & Tecumseh Sts., Winnipeg, Man. (Jan. '49)

Wigglesworth, Armand F., Elec. & Water Supt., Liverpool, N.S. (Jan. '49)

Wingfield, F. E., Water Supt., Muskogee, Okla. (Jan. '49)

Woehler, Bernhard C., Supt., Water Dept., 4801 W. 50th St., Edina, Minn. (Jan. '49)

Wood, C. C., Jr., Water Works Supt., Crystal Beach, Ont. (Jan. '49)

Woods, Fred M., Asst. City Engr., City Hall, Guelph, Ont. (Jan. '49)

Yoder, M. Carleton, San. Engr., Route 3, Box 322, Lodi, Calif. (Jan. '49)

REINSTATEMENTS

Bays, Carl A., Geologist & Engr., State Geological Survey, Box 189, Urbana, Ill. (Apr. '43)

Devers, Theo, Supt., Public Works, Versailles, Ky. (July '41)

Horn, A. John, Chief San. Consultant, 8th Army Military Govt., Public Health Branch, APO 343, c/o Postmaster, San Francisco, Calif. (July '39)

Kellogg, J. Wilford, 1607 Shepard St., Morehead City, N.C. (July '21) *Director '40–'43. Fuller Award '46. P*

Rosen, Milton, Comr. of Public Works, Board of Water Comrs., St. Paul 2, Minn. (Jan. '31)

Springer, John P., Sales Engr., Honolulu Iron Works Co., Box 3140, Honolulu, Hawaii (Oct. '37)

Sturtevant, F. L., Sales Repr., Wintroath Pump Co., Box 371, Lancaster, Calif. (Oct. '46)

Thompson, N. J., Sales Repr., Dresser Mfg. Div., 831 Cherry St., Denver, Colo. (Oct. '39) *P*

Van Pelt, Richard, 1157 N. Cottage St., Salem, Ore. (Apr. '43) *MP*

Velloso, Frederico A. L., Empresa Beta Bahiana de Costr., Avenida Sete de Setembro 50-1 Andar, Salvador, Bahia, Brazil (Jan. '43)

LOSSES

Deaths

Decker, L. L., Supt., Water Dept., Leroy, Ohio (Apr. '43) *P*

Hoy, Joseph A., Supervising Foreman, Water Dept., 18 E. Worcester St., Worcester 4, Mass. (May '22)

Johnson, W. Scott, Director, Environmental Sanitation Sec., Div. of Health, Jefferson City, Mo. (Feb. '24) *P*

Newman, Alfred C., 1107 S. 8th St., Leesburg, Fla. (July '37) *M*

Syme, Jack, Water Works Supt., Almonte, Ont. (Jan. '48)

Resignations

Bellingham Water Dept., Henry J. Donnelly, Water Supt., City Hall, Bellingham 21, Wash. (Corp. M. Jan. '40) *MPR*

Brittain, Earle, Chem. Engr., The U-Need-Us Coal & Chemical Co., 216 Mathews St., Painesville, Ohio (Jan. '47)

Gooch, E. W., City Engr., Water Board, Engr.'s Office, Bellingham, Wash. (Apr. '40) *MPR*

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Hilton, Joe, Member, Board of Water Comrs., Pres., City Council, City Hall, Bellingham, Wash. (Jan. '48) *M*

Mortinson, Severin A., Comr. of Public Utilities, Board of Water Comrs., St. Paul 2, Minn. (Jan. '47)

CHANGES IN ADDRESS

Changes received between March 5 and April 5, 1949

Alexander, Aleck, San. Engr., Kyushu Military Govt. Region, APO 24–5, c/o Postmaster, San Francisco, Calif. (July '48)

Allen, Victor H., 83 Horatio St., New York 14, N.Y. (Jan. '39)

Applebaum, Samuel B., Box 97, Rushland, Bucks County, Pa. (Apr. '16) *P*

Bakkum, Peter, Georgia Inst. of Technology, Box 1509, Atlanta, Ga. (Jr. M. Jan. '49)

Barnhill, Kenneth G., Sales Engr., The Permutit Co., 130 E. 93rd St., New York 28, N.Y. (July '39) *P*

Barrie Public Utilities Com., W. M. Salter, Gen. Mgr., Box 57, Barrie, Ont. (Corp. M. July '35) *M*

Belvidere Water Dept., Wayne Richardson, Supt., City Hall, Belvidere, Ill. (Corp. M. Jan. '48) *M*

Blackshaw, George E., Mgr., Merrick Div., New York Water Service Corp., Box 578, Merrick, N.Y. (Oct. '45) *M*

Campion, Harry, 423 Jefferson Ave., Defiance, Ohio (Apr. '44) *MP*

Carter, H. E., Box 263, Verdugo City, Calif. (July '35) *M*

Castella, William F., Cons. Engr., 1623 Transit Tower, San Antonio 5, Tex. (Apr. '48) *MPR*

Chapman, Howard W., San. Engr., U.S. Public Health Service, 808 Malcolm Drive, Silver Springs, Md. (July '46) *P*

Cleary, Edward J., Executive Director & Chief Engr., Ohio River Valley San. Com., 410 First National Bank Bldg., Cincinnati, Ohio (Jan. '45) *MPR*

Colburn, B. S., Jr., Route 1, Fletcher, N.C. (July '46) *PR*

Cone Mills Corp., J. D. McConnell, Plant Engr., Greensboro, N.C. (Corp. M. July '43)

Dilworth, H. M., 4204 W. 15th Ave., Vancouver, B.C. (Jan. '38) *M*

Dominion Bridge Co., Ltd., Pacific Div., Box 160, Vancouver, B.C. (Assoc. M. Jan. '45)

Durr, John P., Asst. Engr., State Dept. of Health, Bureau of San. Eng., 916 Diamond, Meadville, Pa. (Jan. '46) *P*

Earls, Clifford Elliott, White Star Chemical Co., 2030 E. Adams St., Jacksonville, Fla. (Oct. '43) *P*

East York, Township of, J. D. Corcoran, Comr., Munic. Offices, Mortimer & Coxwell Aves., Toronto, Ont. (Corp. M. Jan. '35) *MP*

Eiffert, William T., Box 422, Route 5, Dayton 5, Ohio (Oct. '45) *MPR*

Fardahl, Nels, Cons. Engr., 1624 S. Harvard, Tulsa, Okla. (Jan. '45) *MP*

Forbes, H. de B., Jr., Lt. Col., Box 363, Richmond, Ky. (Jan. '46)

Forsyth, Joseph R., Morris Knowles, Inc., 819 City Hall Annex, Philadelphia 7, Pa. (Jan. '46) *P*

Francis, James G., Civ. Engr., 4854 Placidia Ave., North Hollywood, Calif. (Oct. '31) *MPR*

Fraser Utility Supply Co., R. J. Fraser Jr., Box 1655, Glendale 5, Calif. (Assoc. M. Oct. '38)

Gotaas, Harold B., Chairman, Div. of Civ. Eng., Univ. of California, 211 Engineering Bldg., Berkeley 4, Calif. (Jan. '38) *PR*

Greece, Town of, Water Dept., Francis J. Cramer, Supt., Box 85, Charlotte Station, Rochester 12, N.Y. (Corp. M. Oct. '35) *M*

Haney, Paul D., U.S. Public Health Service, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio (Jan. '39) *P*

Harding, Robert W., 112—4th St., San Antonio, Tex. (Oct. '35) *Fuller Award* '46.

Hauer, Gerald E., San. Engr., 817 Grand Ave., Aurora, Ill. (July '41) *P*

Hernandez, Donald, 28A N. Weston, Elgin, Ill. (Jan. '48) *P*

Hicklin, Robert G., Mgr., Munic. Dept., Robert & Co., Assoc., Inc., 96 Poplar St., N.W., Atlanta 3, Ga. (Apr. '29) *P*

Hoffman, Howard F., Jr. San. Engr., 2611 Oneida St., Utica, N.Y. (Jan. '45) *MPR*

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Horstmann, F. B., Dearborn Chemical Co., 229 Del Mar Ave., San Clemente, Calif. (June '27) *P*

Kempkey, Augustus, Cons. Engr., 330 Highland Ave., Piedmont 11, Calif. (June '23)

LaMarre, Rene J., Chief Operator, Water Board, Adrian, Mich. (Jan. '35) *Director '47–'50. MP*

LeBosquet, Maurice, Jr., Sr. San. Engr., U.S. Public Health Service, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio (July '35) *PR*

Le Jeune, Robert C., 565 Ann Arbor Trail, Plymouth, Mich. (Jan. '48) *R*

Lieberman, J. A., 4125 Norfolk Ave., Baltimore 16, Md. (Apr. '47)

Lilly, Rodman Grizzard, 7318 W. Kenmore Drive, Norfolk 5, Va. (Oct. '47) *P*

McBride, Samuel P., Asst. Engr., State Dept. of Health, 916 Diamond, Meadville, Pa. (July '39) *P*

McChesney, Don R., Sales Engr., The Permutit Co., 34 S. 17th St., Philadelphia 3, Pa. (Jan. '47)

McKee, Donald M., The Permutit Co., 407 S. Dearborn St., Chicago 5, Ill. (Jr. M. Jan. '48)

Morgan, Clifford L., Civ. & Hydr. Engr., Dana E. Kepner, Mfrs. Agent, 1921 Blake St., Denver 2, Colo. (Apr. '46) *MP*

Newton, Harry E., Professional Civ. Engr., 20 S. Forked Landing Rd., Maple Shade, N.J. (Oct. '40) *MPR*

Parbury, Charles B., Gen. Mgr. & Vice-Pres., Water Works, 374 W. Santa Clara St., San Jose 2, Calif. (Apr. '41) *MPR*

Paulette, Robert G., 454 E. Marlin Drive, Pittsburgh 16, Pa. (July '46)

Phelps, P. E., III, Engr., 4 Acton Pl., Annapolis, Md. (Oct. '48)

Pratt, Jack W., Process Engrs., Inc., 821 Market St., San Francisco 3, Calif. (Jan. '41) *P*

Riepe, Gerald E., Builders Iron Foundry, Inc., 122 S. Michigan Ave., Chicago 3, Ill. (Jan. '47)

Roberts, John S., Jr., West & Holyoke Aves., Beach Haven, N.J. (June '20) *P*

Robinson, J. W., Gen. Mgr., County Water Dist., 4854 S. Church St., Pico, Calif. (Apr. '36) *P*

Rodriguez P., Jesus A., Designing Engr., Esmeralda a Brisas, Anauco 4, Caracas, Venezuela (Jan. '42)

Sawyer, Robert W., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Oct. '32) *PR*

Scott, Rossiter S., 23 E. Eager St., Baltimore 2, Md. (Mar. '22) *P*

Silberbauer, Walter R., Supt., Campbell Water Co., 101 Bland Ave., Campbell, Calif. (Oct. '43) *M*

Smith, George L., Sales Mgr., G. L. Smith & Co., 6450 W. Motor Ave., Milwaukee 13, Wis. (Oct. '45) *P*

Snow, Donald L., San. Engr., U.S. Public Health Service, National Inst. of Health, 3950 Langley Court, N.W., Washington 16, D.C. (Jan. '46) *MPR*

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Spokane Utility Supplies Co., Frank B. Miller, Pres. & Gen. Mgr., Gen. Delivery, Eugene, Ore. (Assoc. M. Jan. '48)

Stevenson, Albert H., San. Engr., U.S. Public Health Service, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio (Jan. '40) *PR*

Stolp, Amer C., Dist. Mgr., California Water Service Co., Box 502, Chico, Calif. (Nov. '33)

Stuart, Charles L., Asst. to Vice-Pres., South Bay Cons. Water Co., 5th Ave., Bay Shore, N.Y. (Jan. '40) *M*

Sussman, Sidney, 708 Garden St., Plainfield, N.J. (Jan. '45) *P*

Swift, Howard Newman, Engr., Board of Fire Underwriters of the Pacific, 302 Security Bldg., 510 S. Spring St., Los Angeles 13, Calif. (Oct. '44) *MR*

Thoman, John R., U.S. Public Health Service, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio (Jan. '41)

Turner, William DeGarmo, Florida Chemical Research, Inc., 241 E. 44th St., New York 17, N.Y. (May '31) *P*

Van Der Lely, J., Shell Oil Co., c/o G. Byers, Shell Bldg., Houston, Tex. (Jan. '49)

Waterman, Earle Lytton, Prof. of San. Eng., 231 Fairview Ave., Iowa City, Iowa (Dec. '22) *Director '38–'41. Fuller Award '45.*

Wheeden, H. Ford, 1525 E. 29th St., Baltimore 18, Md. (July '42) *MR*

Williams, Irvin C., c/o Hotel Little, Pearsall, Tex. (Jan. '46) *M*

Yarabeck, Robert Roland, San. Engr., Black & Veatch, 503—10th Ave., Salt Lake City, Utah (Oct. '47) *MPR*

Zimmerman, Harry F., Daniel Field Airport, Augusta, Ga. (July '47)

Zinsmeister, Herbert F., Engr., Wallace & Tiernan Co., Inc., 230 E. Ohio St., Indianapolis, Ind. (Apr. '47)

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain)*; *C. A.—Chemical Abstracts; I. M.—Institute of Metals (Great Britain)*; *P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (Great Britain)*.

FAR EASTERN SUPPLIES

Australia Seeks New Water Resources. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **51**:430 (Sept. '48). Dam proposed on Burdekin R. 780 mi. north of Brisbane, floodwater to be pumped back over Dividing Range and on to island watershed. Queensland wants Burdekin dam for generation of power as well as irrigation. It proposes dam 100′ high to hold back water for 100 mi. Area would be about 145 sq.mi. with capac. about 5,500,000 acre-ft., to cost £12,000,000, with catchment area of 50,000 sq.mi. Water would be used to irrigate about 400,000 acres. New Stirling Dam in Swanland in southwest corner of state of Western Australia has capac. of 44,000 acre-ft., exceeded by Canning Dam with 73,000 acre-ft. Stirling Dam built in steep-sided valley of Harvey R. Western Australian govt. has long planned building dam on Ord R., in far northwest, to hold 2,000,000 acre-ft. Eildon Weir dam in Goulburn Valley (Victoria) will be among largest earth and rock dams, 244′ high and 2960′ long, and will increase present capac. from 306,000 acre-ft. to 2,350,000, at estd. cost of £9,000,000. In design, conoidal type was preferred to triangular. Type of constr. chosen is earth embankment, constructed downstream from existing dam and connected to it by rock fill, so that new embankment would be stable in itself and would gain reserve of strength from existing dam.—*H. E. Babbitt.*

Fiji Public Water Supplies. JOHN LOGAN BROWN. Surveyor (Gt. Br.) **107**:391 (July 30, '48). Hitherto water supply schemes have conformed to simple pattern. Intake on stream at suitable el. to supply distr. system by gravity. There was no storage (except at Suva) and no treatment except screening at intake. Mains and distr. normally of cast iron although fair proportion of smaller wrought-iron piping found in smaller supplies. Some asbestos-cement piping has been used for 10–15 yr. with satisfaction. Std. fire hydrant 2½″ curbside pillar hydrant. New scheme involves pumped supply from river with coagulation, sedimentation, rapid filtration and chlorination. First completed plant was for Tuva, in '41. 4,000-gph. (Imp.) pump delivers water to dosing and mixing race on upper floor of filter house whence it flows through 2 sedimentation tanks, 6′-diam. filter and chlorinator. Per capita consumption tends to be excessive. To control consumption, policy of 100% metering established. Suva now 10% metered, and consumption is 90 gpd. (Imp.) per capita. In other supplies it is of order of 30 gpd. for metered paying services. Meters are of eccentric-cylinder, positive type. Qual. of water entails fair amt. of maint. on these, and trial lot of rotary meters being installed.—*H. E. Babbitt.*

Water Supply on Java. H. A. D. LINN. Water (Neth.) **32**:187, 201 (Sept. 30, Oct. 14, '48). Consideration of various factors, improvements

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of supply and organization of centralized distribution systems, as well as role surface waters play in public health, leads author to some definite conclusions: [1] generally accepted viewpoint that best supply is that which furnishes bacteriologically pure water is only relatively correct; [2] effort to treat water to eliminate last pathogenic bacterium is detrimental, because substances providing resistance are withheld from consumer, so that medical organization must be available to prevent epidemics; supply of bacteriologically purified water is suitable only for highly civilized peoples with high hygienic standards and good medical service available; since with such supply, immunity to contagious diseases is lost, this solution of problem is unsuitable for primitive peoples, especially in tropics, where people are best served with supply of unpurified river or other water which is not poorer than that commonly used; [3] transportation of such water through open canals improves quality materially under influence of light; [4] improvement of water supply must take place gradually and in relation to living conditions and medical services available; forcing water supply improvement may be backward step in improving health of primitive peoples.—*Willem Rudolfs.*

Drinking Water Supply on Java. SCHAEFFER, C. O. Water (Neth.), **32**:245 (Dec. 23, '48). Linn claimed that providing treated water to natives detrimental (Water, **32**:187, '48; *see preceding abstract*) to public health on Java. On basis of results and experience author concludes that: [1] general public health measures at present more important than individual medical help; [2] provision for bacteriologically safe water should receive priority; [3] assumed danger of reduced resistance to diseases by inhabitants through breaking contact with pold. water not justified.—*Willem Rudolfs.*

Temporary Dam—Cobb River, Nelson [New Zealand]. E. W. HEINE. New Zealand Eng., p. 1081 (Nov. 10, '48). Paper describes constr. of dam to provide addnl. storage for hydroelec. generating station serving Nelson and Marlborough, while main dam some 2 mi. further downstream being constructed. By raising river level 22′, storage vol. of 51,000,000 cu.ft. obtained, representing 1,700,000 kwhr. Dam of compacted earth with impervious core, side slopes being 3:1 and $2\frac{1}{2}$:1. Length 690′, max. height 30′, earth fill 45,000 cu.yd. Work on access road began on Aug. 11, '47. On site first work done was on Aug. 18, consisting of stripping of vegeta-

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tion and topsoil, then excavation of cutoff trench, which varied from 5′ to 10′ in depth. At same time trench cut alongside river for 5′-diam., 8′-long discharge pipes of reinforced concrete. These were dragged into position from downstream side with hand winch, last 10′ or so being placed on layer of stiff grout to form tight joint at bottom of pipe. After placing, pipes were concreted up to centerline and concrete collars poured over each joint, to lengthen seepage line along pipe and provide key with material of dam. Dam built in 2 parts, first up to edge of river and then across river. Core and shoulders built together in 6″ layers compacted with double-drum sheepsfoot tamper. Pneumatic tampers used to consolidate earth close to discharge pipe. Gravel and stone inverted filter drain placed along downstream toe. Upstream face covered first with layer of gravel and then with layer of boulders of 2′–3′ size, to act as wave protection. Concrete spillway, 198′ long, constructed with 45-deg. side slopes and rounded crest, avg. height being 4′. Crest 8′ below top of dam. Equip. used on constr. consisted of two 12-yd. and two 8-yd. carryalls with tractors, one sheepsfoot tamper which was also fitted with blade for general cleanup work, one bulldozer, shovel and dragline machine and dumpers. Despite considerable heavy rain—actually rain fell on 88 days during constr.—work completed on Dec. 16, '47.—*Ed.*

CONTROL EQUIPMENT

Automatic Control Equipment for Water Softening Plant and Filters. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **51**:180 (Apr. '48). Basically controller (for regeneration) consists of revolving drum driven by fractional-hp. electric motor. Drum, fitted with adjustable cams, makes one

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revolution in time required for regeneration, or for performing any other complete process. Immediately below cam drum is relay block containing relay valves, each operated by appropriate drum cam through valve plunger. Any relay valve can be operated independently by hand control. Hydraulically operated valves essential feature of automatic control. Complete and correct sequence of shutting down softener, backflushing, brine injection, rinsing and recommencing softening carried out without attention. Backwashing operations of filter systems carried out in similar manner.—*H. E. Babbitt.*

Rangitita Irrigation Scheme, New Zealand. Remote-Controlled Sluices. Anon. Wtr. & Wtr. Eng. (Gt. Br.) **51**:535 (Nov. '48). Control panel at control station carries lamps, keys and push buttons, and often has single-line diagram of network controlled. These principles have been applied to operation of irrigation scheme in New Zealand. Flow of water controlled by gates of electrically operated vertical-lift or radial type. Single pair of overhead pilot wires, following course of water, links gate locations. Each gate indicated on panel by light and operated by lever-type "select" key. Operation of this key transmits "start" signal to control station equip. and at same time "marks" point on bank of "sending" selector. After delay period, sending selector at control begins to step to find marked point on its bank. At required gate, circuit now prepd. for performance. Control engr. depresses either "up" or "down" push button, as required.

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When desired, engr. presses button designated "indicate." Indicating selector synchronized with receiving selector at gate. Position pointer, on front of control panel, calibrated to record gate position. Stepping and impulsing continue until "stop" signal received from gate. Line protector unit installed at each gate and at control to protect equip. and personnel against excessive voltages induced in pilot wires.—*H. E. Babbitt.*

Progress in Automatic Control. W. STUART MILLS. Wtr. & Sew. (Can.) **85**:7:21 (Jul. '47). Control mechanisms and methods in "continuous-flow" industries have progressed rapidly in last 15 yr. Fundamental factors involved and terminology discussed. Controllers categorized with respect to controlled variable, measuring means, auxiliary power source and controller's responses. Fundamentally, all automatic control problems essentially similar. Ease of application depends largely on absolute and relative amounts of various lags, which are discussed. Response characteristics of pneumatic controllers described with aid of plots based on time of reaction of final control element corresponding to variations in controlled variable.—*R. E. Thompson.*

Electrical Telemetering. A. LINFORD. Wtr. & Wtr. Eng. (Gt. Br.), **51**:106, 167 (Mar., April '48). Telemetering devices increasingly important in large plants where tendency is to assemble all registering elements on central panel. Electrical measurements can be transmitted over any distance and device can be used to transmit value of any measured quantity. Complete electrical telemetering installation consists of four items: [1] mechanical element which detects value of function to be transmitted; [2] transmitter to convert mechanical movement into electrical quantity; [3] receiver which converts signal into indication or chart record of function measured; and [4] transmission line wires. Five main groups of transmitters can be distinguished: [1] *System measuring value of electrical quantity.* At transmitting end, movement produced by mechanical element—e.g., float—is applied to contact arm of variable wire-wound resistor. Arm and one end of resistor connected to pair of transmission line wires. Resistance across line wires varies with function being transmitted. Receiver measures this resistance by means of moving coil element of special design. [2] *Self-balancing system.* Transmitter element consists of variable wire-wound resistor whose contact arm is moved by mechanical device which measures function to be transmitted. 3 line

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wires required; one connects one end of transmitter resistance in series with one arm of bridge, second wire connects other end of transmitter resistance in series with another bridge arm, while third wire connects sliding contact to sensitive galvanometer situated in receiver. [3] *Ratiometer system.* Ratio of inductances of two coils used as means of conveying information. Method of varying inductances depends on effect of closed conductor on coil energized by alternating current. Coil through which alternating current is passing will induce emf. in conductor surrounding coil. If conductor forms closed circuit, current will flow in it. Energy required to drive current must be supplied by coil. Effect is to draw more current from circuit supplying coil. Since same effect would be produced by reducing inductance, it is said closed conductor reduces inductance of coil which it surrounds. Amount by which inductance is reduced depends on coupling between conductor and coil, and effect is greater the nearer they are together. [4] *Impulse system.* Variable-duration impulse (V.D.I.) systems have advantage that accuracy of repetition depends only on timing of impulses, and is independent of moderate changes of amplitude. Kent V.D.I. system works in cyclic fashion, each cycle lasting about 1 min. At beginning of cycle, switch in transmitter is opened and remains open for period less than 1 min., duration depending on value of function to be transmitted. Transmitter switch is connected by 2 line wires to electromagnet in receiver. In Bailey Synchrometer transmitter and receiver are similar since each contains identical cam rotated at constant speed, and pair of contact arms. In transmitter one contact arm is moved up and down by cam. Second contact arm, above first, rests against stop which is

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positioned mechanically in accordance with function to be transmitted. Period of contact between 2 arms depends on position of stop. Receiver contains similar arrangement. Operation of system depends on synchronization of receiver cam with transmitter cam. 3 receivers can be operated by 1 transmitter, and transmission distance is limited only by line resistance. [5] *Electronic system.* Radio valve forms basis of nearly all electronic apparatus. Diode, simplest type of radio valve, consists essentially of 2 pieces of metal in vacuum, one hot enought to emit electrons. Other is cold, and acts as collector of electrons. Hot member (cathode) connected to negative end of d-c. supply, positive pole being attached to cold member (anode) of valve. Due to negative charge, electrons flow opposite to "flow of current" through valve and pass from negative to positive pole. In triode, mesh of fine wire is interposed between anode and cathode. Electric potential of grid is usually few volts negative to cathode. Electrons leaving cathode are repelled by grid and only fraction reach anode. As grid voltage is made less negative, more anode current can pass, and vice versa. In Evershed Electronic Repeater, input required to operate transmitter is torque proportional to value to be transmitted. In normal condition input torque balanced by torque due to coil in pot magnet. When torques fail to balance, pivoted arm turns slightly causing disc contact to touch one or other of fixed contacts. This applies either positive or negative voltage to valve grid and

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causes anode current to change. Receivers used are standard d-c. milliammeters. Number of receivers can be operated by single transmitter. Foregoing examples show each instrument has its own advantages and disadvantages and choice must depend on factors peculiar to operating conditions.—*H. E. Babbitt.*

CORROSION

Amine Volatility and Alkalinity in Relation to Corrosion Control in Steam Heating Systems. A. A. Berk & J. Nigon. U.S. Dept. of Interior, Tech. Paper 714, Washington, D.C. ('48). Investigation conducted as cooperative project of Bureau of Mines, and Repairs and Utilities Branch of Office of Chief of Engrs. Corrosion tests run to compare usefulness of several amines for treatment of steam systems to prevent return-condensate corrosion. For comparison, studies included tests of corrosiveness of condensate from untreated steam of low and high carbon dioxide contents. No active corrosion occurred at any of testers when amines used. No single factor appeared to be responsible for such minor corrosion as was observed in alk. solns. resulting from amine treatments. No unique inhibiting properties peculiar to any one amine found for those studied. Batch feed at 8-hr. intervals appeared to be as effective as continuous treatment for providing alk. condensates and thus preventing corrosion. Corrosion produced by acidic condensate on coiled-wire test specimens tended to be increased by increased carbon dioxide content and also by increased flow. Effect of temp. and D.O. upon such corrosion apparently less important. Data do not warrant more definite conclusions on factors influencing corrosion. More enlightening data expected from addnl. tests now in progress. Of 3

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amines used, cyclohexylamine very volatile in boiling water and quite alk., benzylamine moderately volatile and moderately alk., and morpholine least volatile and only mildly alk. High volatility tends to result in losses during de-aeration; low volatility tends to result in losses in blowdown. High alky. tends to prevent removal of carbon dioxide, thereby increasing percentage recirculation of this substance and its concn. in system. Higher concn. of amine required in system, greater amine makeup required, as, in general, losses due principally to wasted condensate. Concn. of morpholine tends to decrease during distr. of steam at low pressures (5 psi.). Where such lines long and much steam lost through condensation in piping, use of morpholine not recommended. Amine which in very dilute soln. distilled without change in concn. at atmospheric boiling point would then be regarded as having min. required volatility. Calcns. made comparing amine makeup required for each treatment when 500,000 lb. of steam was generated and feedwater makeup, contg. 200 ppm. free and combined carbon dioxide, was 6, 12 and 20%. Comparisons made at blowdown rates of 2 and 5%, based upon load. From standpoint of quants. used, cyclohexylamine appeared to be less desirable than either morpholine or benzylamine under chosen conditions. Morpholine somewhat superior to benzylamine when blowdown small compared to makeup, but reverse true when blowdown made relatively high. These conclusions apply to particular plant that was operated at 60-psi. steam pressure and had de-aerating heater operated at 215°–220°F. At higher steam pressures, comparison probably would be even less favorable to cyclohexylamine and more favorable to morpholine. At lower pressure, inexpensive amine of volatility

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higher than that of morpholine would appear to be most suitable.—*Ed.*

Measurement of Corrosion Pits in Boiler Tubes. B. M. THORNTON. Engineer (Gt. Br.) **163**:229 (Mar. 28, '47). Describes tool designed to detect and measure corrosion pits using electrical instrument for measuring thickness of boiler tubes in place, and of nonferrous castings. New exploring head designed for detecting location and presence of serious pitting. One man moves head steadily through tube, while another watches microammeter.—*Corr.*

Report on Experience With Copper Water Pipes in Soil. Water (Neth.), **33**:15 (Jan. 20, '48). About 50,000 connections made to copper mains; 28% of water industry uses copper pipes for distr. lines. Corrosion seldom occurs and use of copper pipes considered acceptable for all soil and water conditions in Holland; when ground water brackish, caution advised. Use of bronze or red copper couples prevents corrosion.—*W. Rudolfs.*

STERILIZATION

Chlorination of Water Supplies. ANON. Report of the Water Examination Committee, London Metropolitan Water Board (Gt. Br.), p. 3 (Feb. 18, '49). Discusses report of Director of Water Examination, E. F. W. MacKenzie, on investigation of chlorination methods. Mackenzie report considered not only of scientific interest but of great practical importance to board. His conclusions "are the result of long continued researches and are not only valuable from the point of view of health but should also enable the Board to save considerable sums of money." Contributions made by Alexander Houston to practice of water chlorination during

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'18–'19 reviewed, with particular reference to super- and dechlorination as applied to treatment of river water after filtration; no progress made in application of his discoveries at that time. Since '26, terminal treatment of board's river supplies by chloramine process has become standard method of disinfection. Investigations by MacKenzie, in 1932 and subsequently, indicated superior rapidity of chlorine over chloramine as bactericidal agent. Since '40, superchlorination has gradually displaced chloramine treatment of Board's well supplies, without complaint of taste in water so treated, and with detection of no *Esch. coli* in 99.92 per cent of 1772 samples collected. Credit given to elucidation, in U.S., of ammonia breakpoint; and to recent introduction of tests which distinguish free chlorine from chloramine. These contributions have enabled dose of chlorine to be maintained at amount required to effect disinfection and to prevent production of tastes in river supplies after filtration with exactitude previously impossible. As result of these advances, it was decided in '47 to introduce superchlorination treatment of river water on plant scale. Barnes works selected for this experiment because, after filtration, contact period is provided before water passes into distr. system. After minor difficulties overcome, change to superchlorination completely successful. Use of this process was slowly extended and has now been introduced at all board's filtration works. Tabulation shows percentage purity of water pumped into supply from each of works for period during which superchlorination has been used and for corresponding period in preceding year when chloramine was used. A summary of this table follows:

	Samples Negative in 100 ml.—%	
Works	Chloramine	Superchlorination
Hornsey	98.7	99.7
Stoke-Newington	95.0	99.6
Lee Bridge	94.4	99.7
Kempton Park	98.8	100.0
Kew Bridge	100.0	100.0
Surbiton	100.0	99.0
Hammersmith	94.0	100.0
Hampton	100.0	100.0
Walton	98.1	100.0
Avg.	96.8	99.8

Of 3116 superchlorination treatment samples examined, 5 contained *Esch. coli;* these account for 0.2 per cent of samples which were not negative. Four of these occurred when superchlorination could not be maintained, owing to increase in natural ammonia content of water. Fifth bad sample probably due to chlorination difficulties typical of particular works concerned. Results tabulated have been

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obtained at works where contact time usually is only few minutes and where considerable difficulty has been encountered in past in attaining satisfactory degree of disinfection. As superchlorination was so successful, it was considered that prechlorination of water ahead of filtration could be stopped without resultant deterioration in quality of the finished water. Experiment tried at works where quality of filtered water particularly dependent upon this process. Filter effluent became extremely bad, containing up to 90 *Esch. coli* per 100 ml., yet water pumped to distribution after treatment by superchlorination has bacterial purity of 100%. In light of this experiment, it was decided that expenditure of large quantities of chlorine for prechlorination not justified when natural ammonia in filtered water sufficiently low to enable use of superchlorination for terminal disinfection. Prechlorination has, therefore, been stopped at all Thames valley works. Administration of chlorine has been so rearranged that breakdown will be attended by less risk to purity of supply than would have occurred previously. Superchlorination has resulted in more than bacteriological improvements in water quality: first, color reduction of 23%; and second, complete cessation of complaints of chlorinous tastes. Economic aspects of changes recorded are commented upon. Large saving in capital costs is introduced by increased speed with which superchlorination destroys bacteria; reduction is permitted in size of contact tanks in Thames valley to one-half that previously required. Indications are that

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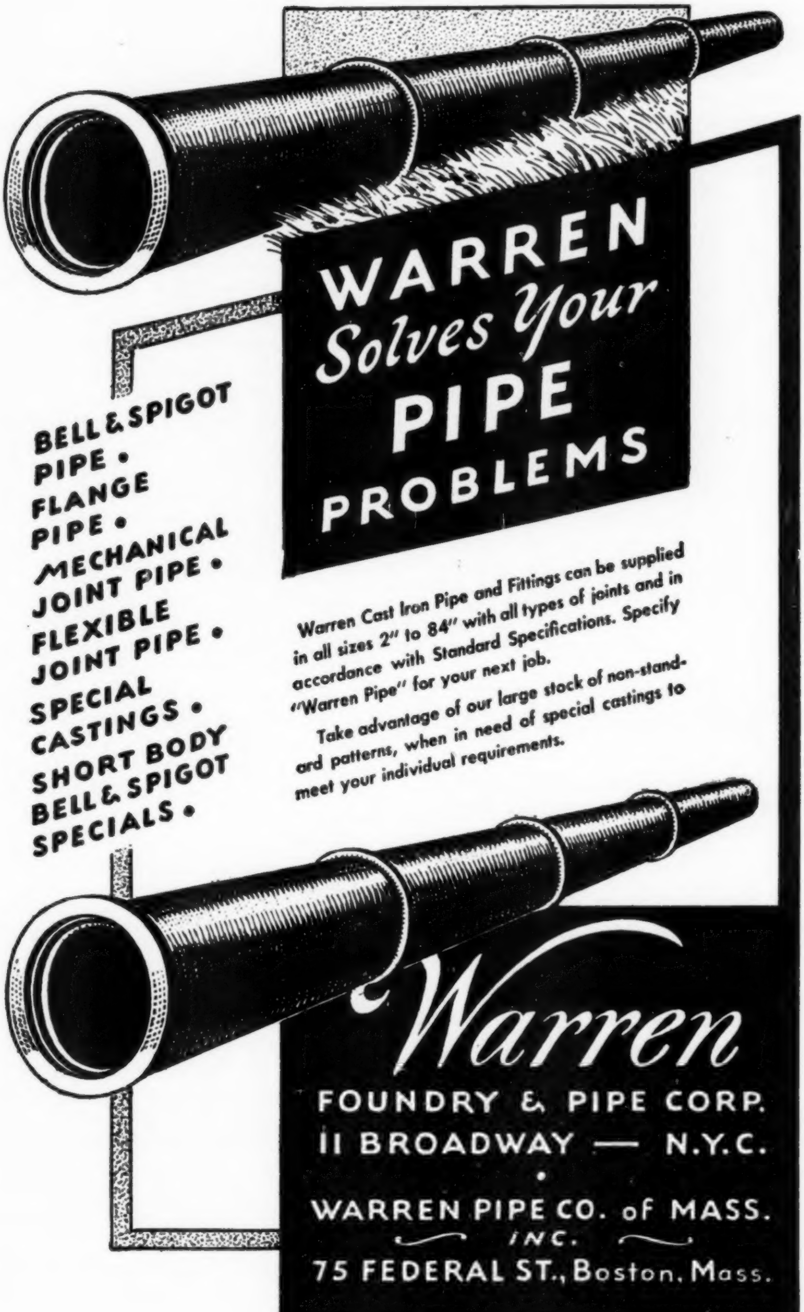
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majority of tastes can be removed by superchlorination, and provision of pretreatment basins for taste and color reduction does not appear justified. Future expenditure of several millions of pounds in construction of capital works and in operating costs would be required, without advantages provided by superchlorination. Full effect of new method upon consumption of chemicals for water treatment has been felt only since Jan. 1, '49, when all prechlorination in Thames valley stopped. Savings shown in following table of avg. weekly cost of chemicals at filtration works have, therefore, been calculated over relatively short period. They constitute a saving at rate of £17,888 per year. Recognized that consumption of chemicals will vary, but annual saving of £10,000 considered to be conservative estimate.

	Avg. Weekly Cost—£ July–Dec. '47	Jan. '49	Weekly Saving, £
Chlorine	363	221	142
Sulfur dioxide	47	0	47
Ammonia gas	121	0	121
Ammonium sulfate	34	0	34
Total	565	221	334

Reviewer's comment: Development described in Mackenzie's report exemplifies application of scientific principles and procedures to solution of problem. Results, evaluated on basis of efficiency and economy, are of pertinent interest in connection with practice of free residual chlorination in U.S. and Canada, where point of application is generally ahead of filtration rather than following it. Implications of report may warrant study to determine those factors favoring prefiltration and postfiltration applications. As noted by Mackenzie, U.S. and Canada have made material contributions to development of superchlorination practices. These contributions, in part responsible for present development, represent only fair return to Metropolitan Water Board for pioneer work of Alexander Houston, their director of water examination who first proposed practice of superchlorination.—*H. A. Faber.*

The Case for Breakpoint Chlorination in Swimming Pools. T. A. KING. Surveyor (Gt. Br.), **107**:243 (May 14, '48). Free residual chlorination consists in application of chlorine sufficient to break down free ammonia, to oxidize all org. matter and to leave in pool at all times free residual chlorine available for immediate germicidal action. In general practice, destruction of free ammonia not specific object and residual not necessarily uncombined chlorine. Distinction is of fundamental importance in breakpoint method. Chloramines have

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considerably reduced power of oxidation. It was thought that by reducing extent of oxidation residual would be available for germicidal action over longer period. However, destruction of bacteria more rapid by chlorine than by chloramines. Because in swimming pools crux is rapidity of action, residual should be free chlorine. Initial stages of breaking down ammonia and other org. matter may require high rate of chlorine injection. If breakpoint has been passed, value of reading for chlorine will not be less than 85% of reading at full development, say after 5 min. By direct observation of numbers using pool and appearance of water, and by use of ortho-tolidine "flash" test, chlorinator can be readily controlled. There should be no difficulty in applying breakpoint method. Other advantages of method of treatment are that it maintains water in good condition, reducing nitrogenous matter and elimg. algae. Objections to its use are that high quants. of chlorine affect bathers' eyes. If pH kept above 7.5, no discomfort experienced by bathers from 2–3 ppm. of free chlorine, or even more, and there seems to be some mitigation of nuisance from chlorinous odors. Observations at 50,000-gal. indoor pool, with 2½-hr. turnover and temp. at 75°F., show chlorine must be kept at 1.75–2 ppm. at shallow end to maintain 1 ppm. at deep end. Evidence is that objectionable conditions not experienced by bathers with residuals in apparently alarming amts. Process offers effective means of maintaining satisfactory qual. of water at all times.—*H. E. Babbitt.*

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Effectiveness of Water Chlorination at Low Temperatures. E. D. Petryaev & N. T. Tayurskaya. Gigiena i Sanit. (U.S.S.R.), **10**:9:52 ('45). Chlorination carried out at 18°, 20°, 1° and 2°C. with equally good results. Contact between active Cl and water did not have to be lengthened at temps. close to 0° and disinfecting power of $CaOCl_2$ remained same within range 1°–20°. Usual dose of chlorinated lime, sufficient to give 0.2–0.4 mg. residual Cl per l. applied to drinking water contamd. with *Esch. coli* (200,000 per ml.). Concordant results obtained after different intervals of time; at 1°–2° bact. count dropped to 19, 8, 12, and 3 bacteria per ml. after 0.5, 1, 3 and 6 hr., respectively. Slight rise after 3 hr. probably due to reduced residual Cl concn.—*P.H.E.A.*

Superchlorination of Snow Water. G. K. Sergeev. Gigiena i Sanit. (U.S.S.R.), **12**:10:25 ('47). Treatment of snow water by chlorinated lime (50 ppm.), followed by charcoal filtration or hyposulfite treatment, serves to purify this common winter water supply only if duration of chlorination sufficient: 3 hr. at 0–3°; 45 min. at 4–6°, 20 min. at 7°C. or above.—*C.A.*

Secondary Appearance of *Escherichia coli* in Chlorinated Water. K. K. Bogolyubov. Gigiena i Sanit. (U.S.S.R.), **12**:10:33 ('47). In attempts to explain occasional appearance of *Esch. coli* in city water supply under conditions which elim. secondary poln. of treated water, most probable explanation is revival of no. of bacteria not killed outright by chlorination. No. of such survivors low, 0.1–1.0% of initial, and usually they do not constitute health problem because of considerably reduced vitality; however, their complete elimn. necessary for reliable water qual. control. Results of studies leading to this end inconclusive, but they indicate need for slow, gradual chlorination; with warm water supply, ammonization also necessity. Principle of rapid superchlorination unsatisfactory from standpoint of "survivor" bacteria.—*C.A.*

"Microspur," a New Means of Sterilizing Drinking Water. Raimund Hey. Zentr. Bakt. Parasitenk. Abt. I Ref. (Ger.), **152**:327 ('48). "Microspur" complex mixt. of Ag salts (compn. not given) whose oligodynamic action more rapid than any Ag prepn. hitherto used, especially if something which will keep reaction acid employed as activator. Compn. of this "microspur agent" not given. Ordinary tap water will be sterilized in 6 hr., but if turbid 34 may be required. If combination of "microspur" and activator used clear water will be sterilized in 1 hr. Turbid waters should first be pptd. and filtered. Waters treated with "microspur" and kept several weeks show sufficient residual sterilizing effect to kill added bacteria within 24 hr. Microspur valuable supplement to other methods of water treatment, particularly because of its persistent effects.—*C.A.*

BRITISH LEGISLATION

The Water Act, 1948. Anon. Wtr. & Wtr. Eng. (Gt. Br.), **51**:226 (May '48). Act concerned with amendments and additions to Act of '45. Provisions do not extend to Scotland or Northern Ireland. Sec. 1 amends definition of "statutory water undertakers" to include those authorized to supply water but not actually doing so. Sec. 2 enables number of powers granted to water plant operators to be combined on one order. Sec. 3 shortens procedure for obtaining powers by order. Sec. 4 deals with supply of water in bulk, to remove

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any doubt that operators could take water in bulk, or whether minister had powers to authorize bulk supply. Sec. 5, Subsec. 1 and 2, provides that experimental borings to ascertain presence of underground water may be carried out in areas covered by water conservation orders; subsec. 3 extends restrictions on new wells and boreholes. Sec. 6 adds new power of entry at all reasonable hours to ascertain whether restrictions on use of hosepipe are being complied with. Sec. 7 makes slight alterations in powers of minister to demand copies of accounts of water companies. Sec. 8 enables water authorities to enter on and survey any land they may propose to acquire, and to carry out experimental borings or other works. Sec. 9 enables statutory operators to pay subscriptions to any association of water operators. Sec. 10 amends definition of "communicating pipe" by enlarging definition of "street" to include either land between main and street, up to max. of 60′ from center of street, or land between main and premises. Sec. 11, Subsec. 1, allows easements to be purchased in place of compulsory acquisition of land; Subsec. 2 allows water authorities to refuse to commence new supply of water where water fittings not in accordance with bylaws; Subsec. 3 provides that repair costs shall be apportioned between owners of premises served by common supply pipes; Subsec. 4 defines people to be held responsible for waste of water by nonrepair of fittings. Sec. 12 places authorities supplying water under Public Health Act of '36 on same footing as those under '45 water act. Sec. 13 gives development corporations of New Towns Act same

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powers to acquire land as local authorities and statutory water operators have, except that special and temporary powers have been excluded. Sec. 14, Subsec. 1, gives minister powers to require information; Subsec. 2 allows minister, when repealing or amending local acts, to effect consolidations also; Subsec. 3 allows minister to vary amount of compensation water; Subsec 4 provides that where new mains are laid under agreement, cost of new service reservoir may be taken into account. Remainder of this section and Sec. 15 deal with right of appeal, interpretation, definitions and necessity of construing '48 act as one with '45 act.—*H. E. Babbitt.*

Rating [Taxing] of Water Works and Local Government Act, 1948. C. D. SHOTT. Wtr. & Wtr. Eng. (Gt. Br.), **51**:321 (July '48). Water is both public utility and health service but so far has not been nationalized. Water undertakings will continue to be taxed and included in valuation lists in future as in past. Method of ascertaining and apportioning net annual value (N.A.V.) still rests on Kingston case of '26, and is known as profits or accounts method (calculation to ascertain what rent hypothetical tenant could afford to pay for undertaking). Starting point gross water revenue; first deduction from gross receipts is for working expenses, including: protection, storage, treatment, insurance and legal expenses. Next come statutable deductions for "repairs . . . and other expenses necessary to maintain hereditament in state to command that rent." Renewal fund built up by hypothetical tenant for ultimate replacement cost. Profitable life of buildings, machines and so on has to be decided upon. Another debatable point is percentage on which renewal fund is to be calculated; formerly 3.5%, now 2–2.5%. Next deduction from gross receipts is tenant's share, which varies with size of undertaking but averages about 10% of gross receipts. Deductions from gross receipts result in figure which represents N.A.V. of undertaking plus taxes payable thereon. Important to appreciate difference between directly and indirectly productive portions of undertaking. Mains smaller than 6″ treated as directly productive, while all other mains and other parts of undertaking indirectly productive. Part of indirectly productive portion will consist of land covered with water, e.g., filter bed. These parts given special tax relief, consisting of reduction from N.A.V. as high as 30% or more. Apportionment of directly productive part on basis of parochial gross receipts. From N.A.V. plus taxes of entire undertaking, is deducted N.A.V. plus taxes of indirectly productive portion. This leaves N.A.V.

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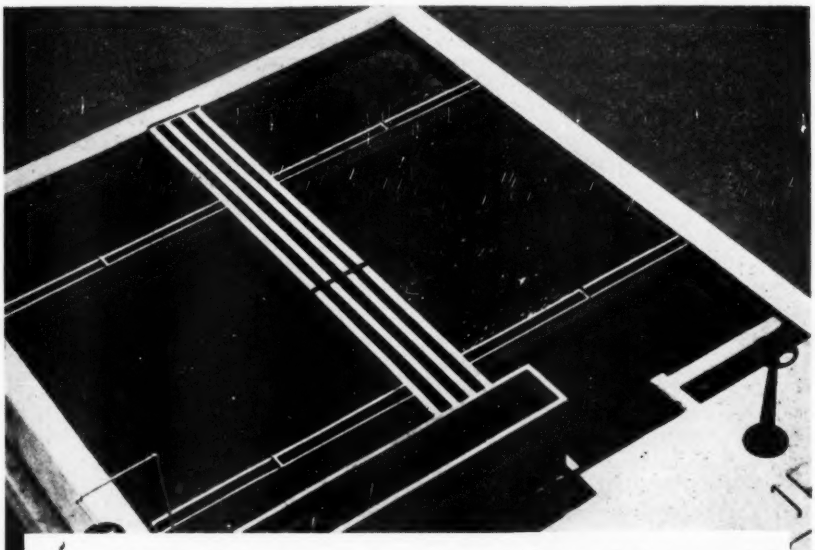

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For complete details on the many other advantages of the Permutit Precipitator, write to The Permutit Company, Dept. JA-5, 330 West 42nd Street, New York 18, N. Y., or the Permutit Company of Canada, Ltd., Montreal.

Permutit

FOR 35 YEARS WATER CONDITIONING HEADQUARTERS

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plus taxes of directly productive portion, expressed as percentage of total water revenue. This percentage then applied to gross receipts in each tax area. Result is N.A.V. plus taxes, and all that remains is to deduct taxes at appropriate poundage for particular area. Local Government Act, '48, puts end to such calculations in respect to railway, canal and electricity enterprises which will make annual payment for benefit of local authorities. Liabilities of these nationalized industries to make payments for benefit of local authorities have been fixed, no matter whether run at profit or loss.—*H. E. Babbitt.*

Implications of Fire Services Act, 1947. ANON. Wtr. & Wtr. Eng. (Gt. Br.), **51**:178 (Apr. '48). Advantages of standardization of procedure by county councils obvious. Many water authorities supply water to several counties and should also standardize procedure and apparatus. Fire authority will endeavor to obtain standard procedure for notification of works affecting water supply and fire hydrants. Machinery for placing orders for new hydrants and repairs will doubtless be standardized to fit in with county's system of accountancy. Fire authorities have no power to enforce installation of particular type of hydrant, water authority still has choice. Valve spindle square, hose connector, and flow under certain head conditions are most important factors and secretary of state is more likely to require uniformity in these than in type of hydrant. Fire authority may request standard form, size and construction of hydrant pit but has no statutory authority to require any particular type of pit. Standardized routine for inspecting and testing fire hydrants may be desired by fire authority. Some water authorities make charge for this service, and possibility of standardized charge arises.—*H. E. Babbitt.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

Industrial Consumption Effects on "Accounted-for Water." H. T. RUDGAL. Wtr. & Sew. Wks., **96**:3:97 (Mar. '49).

Multiple-Purpose Reservoirs—A Symposium. Proc. A.S.C.E., **75**:3:287 (Mar. '49).

The Water Supply Tunnels of the Boston Metropolitan District. KARL R. KENNISON. J. Boston Soc. Civ. Engrs., **36**:1:44 (Jan. '49).

How to Design River-Intake Pumphouses. S. B. ROBERTS. Eng. News-Rec., **142**:9:52 (Mar. 3, '49).

Remote Control Gives Sugar Company Uninterrupted Water Supply. W. A. KELLER. Taste & Odor Control J., **15**:3:1 (Mar. '49).

Ion Exchange in Water Treatment. H. B. GUSTAFSON. Ind. Eng. Chem., **41**:3:464 (Mar. '49).

Sterilization of Cation Exchange Resins. G. A. CRUICKSHANK & D. G. BRAITHWAITE. Ind. Eng. Chem., **41**:3:472 (Mar. '49).

A New Method for Cleaning Settling Tanks. FRED V. H. PIPER. Am. City, **64**:2:102 (Feb. '49).

Tapping and Meter-Setting Practices in Indianapolis. H. W. NIEMEYER. W.W. Eng., **102**:3:208 (Mar. '49).

Safe Disposal of Radioactive Wastes Demands Special Training for Sanitary Engineers. ARTHUR E. GORMAN. Civ. Eng., **19**:3:29 (Mar. '49).

Corrosion Control by the Use of Lime. EDWARD S. HOPKINS. Wtr. & Sew. Wks., **96**:3:94 (Mar. '49).

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Smellbound, we seem these days destined, or at least impelled, to devote our major energies to the omnivorous observation of olfactory phenomena. Thus our every effort to deodorize these columns has been in vain, and we persist in permeating page upon page with the reek of our odious obsession.

This month, for instance, we have paid more than ordinary heed to the predicament of stage and screen star Ruth Chatterton, who was virtually evicted from her Park Avenue penthouse in New York's Ritz Tower because the plebeian aroma of her cuisine offended the delicate snouts of her hoity-toity neighbors. Kitchenette to the contrary apparently notwithstanding, Miss Chatterton was called to court to argue against an injunction that would have curbed her culinary bent. That she was above giving a legal tweak to any of the upturned noses who opposed her, preferring to ply her pots and pans in some less stuffy atmosphere, is, of course, all to her credit, but we are inclined to regret the lost opportunity to get the legal slant on scent and unhappy, too, to know that the Ritz will no longer smell like home.

This was the month, too, when we learned that we would find the new hydrogen isotope, tritium—byproduct of atomic research—a useful plaything in tracing the most subtle odors. This was the month when McGraw-Hill Book Co. brought out *Odors—Physiology and Control,* a 405-page bible of "odor perception, measurement, classification and regulation, with emphasis on practical methods of eliminating odors from factories, homes, public buildings and [unfortunately only] individual persons." This was the month when we got our first sniff of atomizer-applied "Good-aire," a new "aer-a-sol space deodorant," which promises to lick not all, but all offensive, odors in space but without time. This was the month when we learned that smell can sell in direct mail promotional pieces by the use of aromatic inks or impregnated papers, using essences which suggest the product offered. This, then, was indeed a month of months, if not a month to end all months, in smelldom, and, having brought you up to snuff, we shall promise not to raise a stink again until we can announce the discovery of a deodorant which will at last deodorize deodorants.

Not only the sense [or nonsense] **of smell,** but that of sight as well enters into the consideration of water works practitioners on occasion. Ignoring completely, if reluctantly, the implicit pertinence of such terms as "water colors" and "red water," we still find more than a tinge of relevancy in the direct effect of the quality of water on the complex industrial processes in which it often takes part. Exemplifying such a close relationship are

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the trade secrets involved in the production of such peerless antiquities as Stiegel glass and Gobelin tapestry. In Stiegel glass it was the manganic pollution of the process water which contributed the characteristic hue; in Gobelin tapestry it was the wastes from an upstream abattoir which fixed the quality of the dye water and enabled chemists to achieve a remarkable color brilliance. Whether or not Stiegel ever knew his own secret is questionable, but French government authorities somewhat frantically discovered theirs when the slaughterhouse shut down.

How much value water may contribute to other products unique in hue is a matter for speculation, but when the normal naked eye can differentiate as many as 27,000 colors and the trained eye of a textile colorist can distinguish some 100,000, we must certainly credit ourselves with an assist if we can maintain a quality constant enough to be useful as a dye base. As a matter of fact, the very hint that tint has a definite bearing on most of our own activities as well as on those of our fellow fauna invites investigation. Why, we wonder, does the bull see red and the bee not? How can a joke be both colorful and off-color? And more pertinently perhaps, what goes on downstream from the dye works?

A symposium on recent research in water, sewage and industrial wastes will be held in the auditorium of the Department of Commerce, 14th St. & Constitution Ave., Washington, D.C., on June 23 and 24. Papers will be presented by a number of outstanding research workers, and those interested are invited to attend. Further information may be obtained from Henry L. Roahrig, executive secretary of the sponsoring organization, the Sanitation Study Section, Div. of Research Grants and Fellowships, National Inst. of Health, Bethesda 14, Md.

Rubber packing gaskets used instead of jute for pipe jointing are now being produced by Northrop & Co. in sizes for pipe up to 36 in. Formerly the Bond-O line covered only the 4- to 14-in. range of pipe. Gaskets for pipe larger than 36-in. diameter can be manufactured to order.

W. H. H. Putnam has been appointed vice-president and general manager of the Birmingham, Ala., Water Works Co. A graduate of Alabama Polytechnic Inst. in 1927, he has been with the company for 20 years, and now becomes the youngest man to have held his present position.

A new cup disc and piston seat inner valve for their "500" series of regulating valves has been developed by Klipfel Mfg. Co., Div. of Hamilton-Thomas Corp., Hamilton, Ohio. The valve is said to provide a balanced yet tight closing.

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Hard to misinterpret were the opinions expressed by Clay Center, Kan., citizens in their April municipal elections, when they voted 1,026 to 677 in favor of local sale of hard liquor and 1,468 to 254 against building a water softening plant. We'll have a Rock and Rye!

Galvanic protection assumes a new form with the Cor-In Corrosion Inhibitor Zinc Rods, which, fitted with standard pipe-plug ends, screw easily into heat exchangers, pipings and other equipment. The rods come in diameters from $\frac{3}{8}$ to 1 in., with lengths up to 12 in. When the zinc rod is exhausted it can be unscrewed and a refill attached to the threaded plug. Further information from Rotometals, Inc., 980 Harrison St., San Francisco 7.

Robert K. Horton has been appointed a sanitary engineer on the staff of the Ohio River Valley Water Sanitation Commission. A graduate of the Univ. of North Carolina in 1938, Horton has had six years of experience in sanitation programs in South and Central America and has done research on stream pollution and industrial waste treatment.

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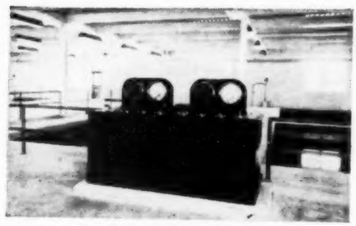
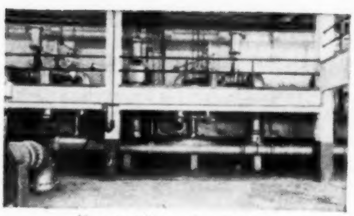
New 40 m.g.d. Filter Plant at the City of Savannah, Georgia.
Consulting Engineers:—J. E. Sirrine Company
General Contractors:—Virginia Engineering Company

AGAIN it's
ROBERTS FILTER
SAVANNAH, GEORGIA



Roberts Operating Tables



Upper and Lower Pipe Gallery

Compact Pipe Gallery
Made Possible by Roberts Waste Valves

View of Operating Floor

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Weather hasn't worn us out yet—either naturally or synthetically—but in some sectors there appears evidence of attrition. Out at Fort Scott, Kan., for instance, weather observer Frank Hewitt quit his job with the plaint that this winter had brought too much ice, cold and snow for any conscientious weather man to cope with. And Sunday supplement meteorologists appeared relieved to be able to turn to billion-year surveys proving that milder climates were gaining a foothold all over the world in preference to day-to-day divinations. Finally, the *Niagara Pioneer* in a feature article entitled "Man-Made Rain (Conclusion)" joined the Air Force and a host of other scientific sages in writing off cloud-seeding as latter-day witchwork.

On the other hand, *Sewage Works Engineering* ignored official disillusionment in gleefully reporting the infallibility of aerial cowpuncher Charlie Barnes, who recently herded three storms into Big Bear Lake, Calif. And *Engineering News-Record* continues to ride the fence with us, reporting such items as the *Yale Law Journal* proposed legislation to prevent irresponsible rainmaking by limiting weather modification activities to federal government agencies or their contractors. Meanwhile, we watch with impatient interest the progress of the continuing experiments of General Electric Drs. Irving Langmuir and Vincent Schaefer in their "Project Cirrus." Certain that weather itself is going to stick with us for a while yet, we are certain too that scientists aren't going to be content with a hands-off policy. Thus we're awaiting now the development of a cloudless dry rain that will inconvenience no one.

Rossiter Scott, who retired some time ago from his position with Dresser Mfg. Div., recently suffered a heart attack, which has left him partially paralyzed. He is now in the Fort Howard Hospital, Baltimore, and is expected to remain there for some time. His place at Dresser has been taken by Arthur Hicks.

Service Lines

"Lime Handling, Application and Storage" is the title of a 71-page book written by Willem Rudolfs and distributed by the National Lime Assn., 927 Fifteenth St., N.W., Washington 5, D.C. Intended to aid the user and engineer in selecting the proper type of lime for his particular requirements, and to indicate the best methods for handling and feeding it, the book includes a compilation of data on the principal types of feeders, slakers, hoppers and solution pots, with a summary of the characteristic advantages and disadvantages of each. Some related information on other water treatment chemicals is also given. Single complimentary copies are available from NLA at the address given above; additional copies cost 50¢ each plus postage.

Altitude measurements for pipeline profiles, watershed and dam surveys and other mapping uses are quickly and accurately made with W&T Sensitive Altimeters, now provided in a shockproof metal case inside the leather carrying kit. A description and specifications are contained in Publication No. TP-24-A, from Wallace & Tiernan Products, Inc., Belleville 9, N.J.

"Industrial Waste Disposal" is the title of Industry Data Bul. 138, published by the Bristol Co., Waterbury 91, Conn. It describes the application of automatic pH recording and controlling instruments and recording flowmeters to industrial waste disposal operations.

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A water hammer arrestor produced by the Wade Mfg. Co. of Elgin, Ill., is said to eliminate damage from this cause in any industrial or domestic application. The device, named Shok-Stop, consists of a permanently sealed air chamber protected against water logging by a metal bellows which allows free expansion and contraction of the sealed-in air, but prevents contact with the water. No servicing or maintenance is required. A 12-page booklet, "The Cause and Cure of Water Hammer," contains full details, and is available on request from the company.

A multi-outlet strip for laboratory use is described and illustrated in a bulletin issued by Eberbach & Son Co., Ann Arbor, Mich. Six standard electrical outlets 6 in. apart are provided on the strip.

Written for the layman by C. M. McCord, director of the Memphis, Tenn., water division, and designed for distribution by water utilities to their customers, the booklet "Water Metering and Water Estimating" is again back in print. The pocket-size, 12-page pamphlet was used as a public relations aid until wartime shortages curtailed its production. It is available in quantities at nominal prices from the Ambassador Co., Temple, Tex.

A new line of a-c. arc welders, offering increased welding range, stepless precision current control and built-in power factor correction, is described in publication GEA-5279 of General Electric Co., Schenectady 5, N.Y.

Neutralization of industrial wastes is the theme of a 20-page illustrated bulletin—No. ND44-96-708—issued by Leeds & Northrop Co., 4934 Stenton Ave., Philadelphia 44. Two available pH control systems are described: Micromax Electric and Micromax Pneumatic Control.

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